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19 June 1981

Japan Report

(FOUO 37/81)

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POLITICAL AND SOCIOLOGICAL

CITIZENS' ANXIETY OVER DEFENSE, SECURITY REPORTED

Tokyo MAINICHI DAILY NEWS in English 25,26,27,29,30,31 May 81

[First 6 installments of a 12-part article: "Anxiety Over Defense & Security"]

[25 May 81 p 1]

[Text] There has been growing anxiety in Japan over the security of the sea-lanes in the south as well as over the oft-repeated "Soviet threat" in the north.

Against this backdrop, Japan's defense budget has grown steadily while calls are being increasingly heard for the legislation of a new "Constitution," nationalization of Yasukuni Shrine, a Shinto sanctuary dedicated to the war dead, and state control of education.

Theories advocating "faith in national power" and "national interest" have been gaining momentum--more than ever before.

These political phenomena are derived from the "crisis" or "national defense buildup" concept which has been prompted by recent international tension.

The MAINICHI DAILY NEWS reports, in 12 instalments, about the lives of the Japanese who live with growing feelings of "crisis" toward national security.

Coexistence With the Soviets

On a snowy day in February this year, a Russian-language broadcast, originating from Sakhalin, reached — as usual — Wakkanai City in the northernmost island of Hokkaido. It could be heard clearly in the city which is some 42 kilometers from the tip of the Soviet-held island.

Fishermen in the municipal fishermen's association were talking about the poor haul of a boat which had earlier participated in a joint Soviet-Japanese fishing operation in the Okhotsk Sea.

Despite the official quota — 600 tons of prawns, the ship owner said with a wry smile, the actual catch was only around six tons. He protested, "I paid the Soviets 25 percent of the haul as fishing fee. The profit? About 300,000 yen at best..."

The fisherman explained that he has been taking part in the joint operation for the past several years — and has suf-

fered losses amounting to 100 million yen.

Why do so many fishermen set sail for the north sea to risk such massive losses?

An association official said, "This is because fishing is the only means of making a living in this city." Under private agreements with the Soviets, local fishermen are allowed to catch prawns and crabs.

Fishing Industry

The Japanese fishermen hope the fishing agreements will be expanded so that they will be able to catch Alaska pollack, a delicacy in Japan, in the near future.

Since 1977, operations of Japanese pelagic and offshore fishing boats have been restricted by the 200 nautical-mile zones declared by foreign countries. Ships belonging to the local fishermen's association have been seriously affected by the restriction. As a result, hauls of Alaska pollack have been reduced from 580,000 to 260,000 tons over the years.

"The poorer the haul, the higher the price," lamented the association official. "Yet, the cost of fuel oil and fishing gear keeps rising. We can hardly make both ends meet."

It is true that more and more fishermen are idling their time away during weekdays.

Wakkanai Mayor Tatsuo Hamamori said that both municipal and prefectural governments will set aside a special budget of 8 million yen to study the introduction of Soviet natural gas from the Sakhalin continental shelf to Hokkaido. Mayor Hamamori said enthusiastically, "Both West Germany and France receive Soviet gas over 3,000-kilometer pipelines. Why shouldn't this city take advantage of our geographical proximity in laying pipelines between Sakhalin and Hokkaido?"

The mayor said that Soviet natural gas would help Japan cope with the energy crisis.

Our Neighbors

Both the mayor and the fishermen's association official stressed that although Japan should keep its mutual security treaty with the United States and maintain the Self-Defense Forces, the Japanese must coexist with the Soviets—Japan's neighbors.

But an adverse wind is blowing from the central government. An official at the Agriculture, Forestry and Fisheries Ministry said that "it's their (fishermen's) responsibility to participate in the joint fishing operation. But the Soviets make light of the Japanese fishermen who appear willing to yield to whatever conditions the Soviets propose."

Japanese government officials are rather cool toward the Sakhalin natural gas project. Instead, the transportation of the gas by ship between Sakhalin, Tokyo and Osaka is being taken up for discussion on a private basis. If such talks produce a business contract, it is likely that Wakkanai City will be left out.

City officials are trying desperately to win Soviet favor by opening a Japan-Soviet Friendship Hall — in the hope that a ferry service will be linked between the city and Sakhalin.

A city official said that both the Soviets and the Americans are very cheerful individually, adding: "But once they sit down to state-level talks, they change their attitudes toward a spirit of nationalism — something the Japanese cannot easily comprehend."

[26 May 81 p 3

[Text] Return of Four Northern Islands

In the mayor's office from which snow-covered Kunashiri Island can be seen in the distance, Nemuro Mayor Isao Terashima met two New Year's visitors. The two visitors argued in the mayor's presence about the return of the four Japanese northern islands held by the Soviet Union.

"How irresponsible you are to advocate the return of only two islands," one guest told the other, who readily retorted, "Don't talk nonsense. Be more realistic about the actual situation surrounding the four islands."

The mayor listened to their argument in silence.

One guest was Shoichi Takamoto, president of the Nemuro Fishery Association and the other Mitsuo Yanami, chairman of the Nemuro municipal organization to promote the return of the four northern islands.

Takamoto, who supports the return of two islands "for the time being," said that "fishermen in this city have been completely exhausted by the northern islands dispute." He stressed that they cannot wait patiently for the four islands' return in view of their hard-pressed living.

2 Islands First

"Japan should sit for negotiations with the Soviet to let Moscow return two islands," he insisted. "It's a matter of life or death for local fishermen."

The four islands in question are Kunashiri, Habomai, Shikotan and Etorofu.

Takamoto said that at talks held between Tokyo and Moscow 25 years ago, the Soviet Union promised Japan that they would return the Habomai and Shikotan islands to Japan only when a peace treaty is initialed by the two countries.

"But no islands will be returned to Japan as long as Japan maintains the mutual security treaty with the United States and regards the Soviet Union with hostility," he said.

On the other hand, Yanai asserted that some 17,000 Japanese were forced to leave the four islands at the end of the last war. "Some 30 percent of the evacuees are dead, unable to realize their dream of returning to the islands," he went on. "Now that the central government has started — in earnest — to promote the return of the four islands, such a 'weak-kneed' compromise should not be voiced."

"How can we connive at 'unlawful Soviet occupation' of the islands," he added. "For the benefit of the local economy, too, we cannot put the islands in 'Soviet hock.'"

The Nemuro municipal office has opened the Nemuro-Soviet Friendship Society in the city hall, promoting various Russian cultural programs for local residents.

The society has suspended the programs since last year after the return-the-four-islands campaign gained momentum.

A group of local fishermen were seen working for a city construction project. A city official said they were on a public relief work project because of recent poor hauls. Because of poor business, the official explained, the tax collection ratio in their city is the lowest among the 31 cities in Hokkaido.

18 Bil. Subsidy

To help revitalize the city, the central government will shortly extend a subsidy totaling 18 billion yen to Nemuro and three other neighboring towns for the construction of an observation tower on Cape Nosappu, highways and ports. Artifical fish breeding is also envisaged.

Hanasaki Port, once the most thriving salmon-trout fishing port, has been hit by the business slump. A local primary school principal said the number of schoolchildren at his school has decreased by 100 to 180 during the past three years. The school is known for its education encouraging the return of the four islands.

The principal said a recent opinion poll conducted among children indicated that they regard the Soviets as a cunning, impudent, greedy and treacherous country.

He also said that the children, when asked what Japan should do in return for the northern islands, replied that Japan 1) should promote friendship with the Soviets, 2) should start war with the Soviets, and 3) should attack the Soviet Union with nuclear weapons, in this order.

The children's opinions may be reflecting those of their parents.

[27 May 81 p 3]

[Text] Poachers Active Behind Scenes

Some 30 urchin poachers were operating near the Soviet-held Kaigara Island. This was some 3.7 kilometers from Cape Nosappu. Yet, the area beyond 1.8 kilometers from the cape is within "Soviet territorial waters."

Both Japanese and Soviet coast guards patrol their territorial waters in close proximity. Most Japanese poaching boats are equipped with two powerful American-made outboard engines. They can cruise at the maximum hourly speed of 80 kilometers, far surpassing the speed of Japanese and Soviet patrol boats.

In addition, these poachers can "easily" enter Soviet territorial waters, to the chagrin of Japanese patrol officials. One official said that they were very cunning and elusive, always monitoring patrol information beforehand.

Among the poaching boats, some 30 "repo" boats are active on the scene. The "repo" boat is a vessel which is allowed to operate in Soviet waters freely in exchange for giving the Soviets expensive gifts and/or sensitive information on Japan.

Japanese police officials said that the gifts that Japanese poachers have given the Soviets include color TV sets, pantyhose and even Japanese-made bulldozers, adding that bulldozers, believed to be gifts from fishermen, were spotted running on Kunashiri Island from time to time.

'Repo' Boats

The owner of "repo" boats lives in an imposing mansion-like residence located on a hilly section of Nemuro City. Three collies romped in the snow-covered front yard. Neighbors said his residence has six rooms on the first floor and six rooms on the second floor, adding that the owner has 10 "national treasure-class" Japanese swords.

Urchin poachers can make a haul worth 400,000 to 500,000 yen in two or three hours of fishing, it is said. Police reported that 107 poachers were rounded up last year. Officials could not arrest the poachers, however, in violation of the Emigration and Immigration Control Law because the fishing grounds where they poached are originally within Japanese territorial waters.

The waters around Kaigara Island were the "richest" fishing grounds for local fishermen until recently. In the 1950s-60s, fishermen caught sea tangle by risking arrest.

The late Tatsunosuke Takasaki, then chairman of the Japan Fisheries Association, took a serious view of the Japanese fishermen's risky operation and devoted most of his later years to the conclusion of a private fishing agreement with the Soviet Union.

Subsequently, Japanese fishermen were allowed to catch sea tangle for about 14 years in exchange for paying the Soviets fishing fees.

As a result, the local economy turned for the better, resulting in the construction boom of fishermen's houses.

Negotiations In '77

A director at the Nemuro Fishermen's Association said that Prime Minister Zenko Suzuki must be well aware of the negotiations the Japanese had with the Soviets in Moscow in 1977.

Suzuki, then minister of agriculture, forestry and fisheries, who was negotiating with the Soviets over the demarcation of a 200-nautical mile fishing zone, said:

"I want Japanese fishermen to continue catching sea tangle around Kaigara Island. But the Soviets insist that Soviet fishing be allowed within Japanese waters..."

The director, who was also in Moscow for the negotiations, said that "if the Japanese delegation permits Soviet fishing in Japanese waters, the Diet ratification of the fishing agreement will be ruined. We'll, therefore, give up catching sea tangle at Kaigara."

Local fishery officials have been visiting Moscow to seek Soviet permission for Japanese sea tangle fishing. The Soviets only repeat that Japan should obey Soviet law.

If the Japanese observe the law, the officials fear, Japan's claim over the four northern islands will crumble.

Local fishermen are hard-pressed because of chronic poor hauls. The fishermen's association is reportedly suffering from a debt of some 12 billion yen.

One elderly fishermen said, "Why shouldn't we obey Soviet law? Will observance of Soviet law impair the prestige of Japan? We're struggling for our living..."

[29 May 81 p 3]

[Text] Beyond Hatred in the Past

A monument standing on a beach at Sarafutsu Village, about a one-hour automobile ride from Cape Soya, is dedicated to the souls of some 700 Soviet sailors who died in the sinking of a Soviet freighter in stormy seas off this village in December 1939.

The tragic incident occurred half a year after the Japanese Kwantung Army suffered a crushing defeat at the hands of the Soviet Army in the famed Nomonhan Incident.

A village official explained that villagers recovered the bodies of Soviet sailors, cremated their remains and prayed for their souls even during the last war.

The Japanese military police often tried to stop the villagers from observing the anniversary of their deaths, saying "Why do you have to pray for the souls of men from a Red country?"

Local Opposition

Ten years ago, on the 33rd anniversary of their deaths, a move was initiated by some villagers to build a cenotaph. Although some residents, who were formerly evacuees from Sakhalin, opposed the move, they finally agreed to donate money for the construction of the monument.

Later, Wakkanai City and other towns joined in the fund-raising drive.

The Soviet-Japan Friendship Memorial Hall stands in front of the cenotaph. The hall, which was built with donations from the Soviet Union, displays Russian folkcrafts and costumes in showrooms.

Also on display was the image of Nikolai Lenin.

The village official said he was drafted by the Japanese Imperial Army to fight in Manchuria in 1945. After the war, he said, he was forced to work as a POW for the Soviets in Tashkent for three years.

"I was engaged in canal-ditching work under terrible conditions — lack of food, cruel temperature — burning hot in the daytime and freezing at night, and unsanitary conditions," he recalled.

"I was lucky I was able to return home alive and well. Do I have spite against the Russians? No, I don't feel any bitterness toward them any more. I know I've overcome my old hatred of the Soviets."

Friendship Halls

Soviet-Japan Friendship Halls are located in Sapporo, Kushiro and other cities. The hall in Sapporo City is at present holding various lecture meetings on Soviet culture as well as a Russian language course for the benefit of local citizens.

From the top of the hall in Sarufutsu Village in northern Hokkaido, one can look over the North Okhotsk Sea and the Sarufutsu plain, a tundra-like peat moor where the Imperial Army built an airfield before the end of the last war by mobilizing 300 Korean workers.

Some 150 Korean workers died by the war's end.

A cenotaph was built at a temple in memory of their souls.

A 72-year-old priest, who was formerly an Imperial Navy officer, built the cenotaph to atone for the crime the Japanese Imperial Army had committed against the Korean workers.

The priest, who fought in the Marshall Islands in the Pacific, explained that "the Korean workers were brought here and forced to work despite meager food rations."

Worse still, he said, Japanese soldiers shot and killed Korean workers who attempted to flee.

The airfield was completed but only one aircraft took off from the airfield—three times by the war's end.

The Buddhist priest said that most victims were brought from the northern part of Korea (presently North Korea), adding that because North Korea and Japan have no diplomatic relations, the North Koreans cannot visit the cenotaph.

And now, people who are concerned about the Soviet threat say that Soviet troops may occupy the moor and build an airfield should hostilities begin.

[30 May 81 p 3]

[Text] SDF Presence in Okinawa

Recent opinion polls show that the majority of Japanese people approve of the Self-Defense Forces. In Okinawa, which is known as an "antiwar prefecture through and through," more and more people are acknowledging the SDF.

Ten years have passed since SDF personnel were stationed in Japan's southernmost prefecture. Although the Okinawa people had long opposed SDF recruitment, the present (Junji) Nishime administration formally authorized recruitment of SDF personnel, thus imperiling the antiwar stronghold in the island prefecture.

A 59-year-old Okinawa prefectural assemblyman, who was formerly a major general of the Ground Self-Defense Force, recalled the day when the first SDF detachment landed in the prefecture amid jeers and signs of protest from some 30,000 antiwar, anti-SDF demonstrators.

Because of growing anti-SDF sentiments, the assemblyman went on, SDF personnel were provisioned for a long siege.

Compared with the event 10 years ago, he stressed, a debate at the prefectural assembly over the authorization of SDF recruitment last year was an easy job.

The Liberal-Democratic Party assemblyman spoke in support of recruitment.

Defying heckling from opposition assemblymen, he said that the SDF is serving the public in many ways, adding that "for instance, SDF helicopters ferry the sick and injured from remote islands to hospitals in the city on mercy missions."

He continued in protest, "Why is the SDF called a killer group?"

The prefectural assembly hall was thrown into utter confusion as opposition assemblymen reacted strongly to his speech. Opposition assemblymen and antiwar groups immediately staged a massive rally in and around the hall against SDF recruitment.

On Dec. 24 last year, the assembly authorized recruitment by a vote of 23 to 22.

SDF 'Counteroffensive'

It is said that the SDF's "counteroffensive" is remarkable in the antiwar prefecture. For example, the SDF forced a local education board to invite SDF personnel, who had turned 20, to a Coming-of-Age ceremony in January this year despite the board's original refusal to do so.

High-ranking SDF officials said that they refused the education board's original decision because it would violate the human rights of SDF personnel.

Then the official invitation came to the SDF barracks rather belatedly, the officials explained.

A leader of the Okinawa Teachers Union which is opposed to SDF recruitment said that "since Nishime became Okinawa governor, the SDF's 'pacification' activity has gained ground, and more and more uniformed SDF officers have been visiting the governor's office at all times of the day.

And, the leader explained, the more the SDF is helping Okinawa in civil projects—the construction of roads and fishing ports, the soundproofing of buildings, dud disposal and so forth—the more and wider support the local people are extending to the SDF.

A recent newspaper survey showed that the number of Okinawans who still oppose the SDF account for only one-third of the total population.

More Recruits

SDF recruiting officers said that more and more local youths had joined the forces in recent years, with the number of recruits for 1979 totaling 213.

Anti-SDF leaders said that they would never yield to the ever-growing SDF presence in the prefecture, adding that the opposition is now geared up for a unified anti-SDF movement.

It is true that more and more Okinawan people do not identify the SDF with the defunct Imperial Army, which ignored human rights and even the lives of many islanders during the last war.

One local primary school teacher lamented that schoolchildren learn about the tragedies of the last war that befell the islanders, but soon forget about them. "They visit various battlegrounds like Mabuni Hill," the teacher added, "but they don't seem impressed as much as I thought they would."

[31 May 81 p 3]

[Text] Chitose--SDF Base Town

Citizens of the city of Chitose, which is often referred to as the "front door" of Hokkaido, coexist well with the Self-Defense Forces. The city has a population of 67,000, including some 20,000 SDF personnel from the GSDF Seventh Division and the ASDF Second Air Wing.

The city has 32 assemblymen, 10 of whom are formerly SDF personnel. The mayor holds the title of "president of an assistance and friendship association for the SDF."

A ranking city official said, "We regard the SDF as a big enterprise because we can depend on it for the city's economic development."

The city's finances are in the black. During the past 10 years, the central government has extended some 27 billion yen in SDF-related subsidies to the city.

It is well known that the government is subsidizing the municipal government in the hope that the citizens will fully support and even assist the SDF units, the only combat-ready fighting force in Hokkaido.

One business executive, who was recently transferred from Tokyo to Chitose, said he was surprised at how warmly municipal assemblymen greet and treat the SDF officers and men.

One independent assemblyman who recently bolted the Japan Socialist Party said that "it is nonsensical to call for the abolition of the SDF which is of great help to the development of the local economy."

Snow Festival

The SDF is instrumental in holding the Sapporo Snow Festival, which is becoming more and more famous at home as well as abroad in recent years.

Each year in mid-January, tens of thousands of SDF personnel and hundreds of dump trucks are mobilized for about two weeks to transport snow and ice to the festival site and produce gigantic sculptures in the form of Japanese legendary figures or TV monsters.

Festival officials are thankful to the SDF for their snow and ice sculptures — a major attraction in the festival. Yet, local women's groups have voiced their opposition to SDF assistance because "it smacks of military revival in Japan."

One ranking SDF officer confided that the SDF's participation in the snow festival is somewhat of a burden because they have to "do field training daily."

He added that "we're participating in the festival in a bid to promote understanding and friendship with the local people."

Tsuburaya Race

The Tsuburaya Memorial Marathon was held in Koriyama City, Fukushima Prefecture, last November, and participated in by local citizens and SDF personnel. The memorial race is observed annually in memory of the late Lt. Kokichi Tsuburaya who placed third in the marathon in the 1964 Tokyo Olympic Games.

He was a man of small build — just 162 centimeters tall weighing 54 kilograms — but though completely exhausted, he finished the race which impressed the Japanese people deeply.

Then-DA Director General Junya Koizumi, delighted with his outstanding performance, conferred a special medal on Tsuburaya, then a sergeant.

Four years later—on Jan. 9, 1967, shortly before the Mexico Olympic Games, he committed suicide leaving a note to his parents which read: "I'm too tired to run..."

The late novelist Yukio Mishima lamented his death as a "heroic death." He was promoted to first lieutenant posthumously.

Asked about the memorial marathon race, a local senior high school principal said that students participate because it is a sporting event.

It is believed, however, that the SDF is promoting the event to publicize itself as well as to promote mutual understanding with the citizens.

CSO: 4120

SCIENCE AND TECHNOLOGY

BASIC TECHNOLOGY'S SYSTEMATIZATION, CONSOLIDATION ESSENTIAL

Tokyo NIKKEI ELECTRONICS in Japanese No 262, 13 Apr 81 p 251

[Article by Taro Kuninobu, president of Matsushita Electronic Parts]

[Text] Production Scale of Japan's Electronics Industry....

An industry cannot grow if it hangs onto a single article and tries only to improve and renovate it. It can grow only by developing new technologies and new products. In the case of the electronics industry, there are the beginnings for new undertakings involving super LSI (large-scale integration), optical communications, robots, and new materials such as amorphous and ceramic. And many more new fields will open up as a result of research and development undertaken today and tomorrow. Furthermore, when we look at the field of application we can easily see that electronics have infiltrated deeply into every single industry so that its base has expanded enormously. However, application of electronics to various fields has just started. Based on these observations, the electronics industry is expected to continue to grow for some time to come.

Sales Scale....

Sales last year reached 200 billion yen without counting connection, and 225 billion yen counting connection. Of these, sales related to VTR (Video Tape Recording) excluding tapes amounted to 17 percent or so of the total sales volume. Production of VTR tapes has reached a volume of 1 million reels a month. The export rate of single units amounted to approximately 20 percent of the sales of this company, and the export rate is expected to increase continuously in the future.

The 1981 sales goal with a 35 percent increase is expected to be achieved with confidence. For the next 10 years, an average annual growth rate of 10-15 percent appears quite feasible. In the past, our business was centered around parts and accessories. The constitution of the parts business has changed drastically in recent years. The work process has undergone a fundamental change from manufacturing parts such as resistors and condensers to manufacturing systems and subsystems. As a result, the added value increased and so did the sales. Those lines of traditional and older products have been further reduced in size and increased in reliability. On the other hand, many lines of new

products are being developed aggressively. We wish to succeed especially in the field of manufacturing parts consisting of semiconductors and ICs from systematization of operation.

Number of Employees....

The total number of employees included in related companies is today 12,000. During the past 5 years, our sales scale approximately doubled while the number of employees remained the same. We feel that we can increase production without increasing the number of employees appreciably.

Whether Productivity Will Continue To Increase....

Probably there is much room for further rationalization. However, rationalization does not mean reducing the number of employees or holding down wages. In order to manufacture a product of extremely high precision, quality, and reliability, human hands are no longer dependable; we must depend on machines to do this type of work. This type of work consists of a mixture between mass production of a small variety of parts and small volume production of a large variety of parts.

Most of the parts which are mass-produced are either systematized or made in board form. However, there is still a considerable market for industrial parts. Systematization belongs to the future. Systematized products have larger added values naturally, so that the productivity will increase. The personnel expenditure will not be the main part of the production cost in the future. The indication in recent years is to count "the depreciation cost and the material cost as the basic cost."

The Leading Products in the Future....

The leading products in the future will be those related to communications, memory, and recording. Computers, especially, will become household articles soon. And every computer needs its memory. We will develop from scratch new memory devices using magnetic materials. In fact, there are so many things that we can do that we are at a loss which one to develop first.

The Fund for Research and Development....

Officially it is said to be 3 percent of the sales. But this includes only the direct cost of the research and development groups belonging to various Matsushita research centers. The shape and performance of every electronic part will not remain fixed for long, but will change and make progress step by step. Therefore, if the research and development expenditure of every business department is included, the total research and development fund comes to approximately 10 percent of the sales. As the goal becomes better defined in the future, the ratio of the research and development fund to sales probably will decrease gradually. The ratio is probably at its peak today.

The Fields in Which Research and Development Will Be Emphasized in the Future...

There are many. We will try to find the best materials for various electronic parts, be it the base material for the magnetic tape, magnetic material, or amorphous material.

The Strength of International Competitive Edge of Electronic Parts....

We will remain strong for a long time to come. For example, if what we are doing is taken up by the developing countries of today, there are always a large number of new things that can be done such as developing new technology to increase further reliability and Japan's industry is in a good position to undertake these challenges. This is the national character of the Japanese which cannot be changed in a short time.

9113
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SCIENCE AND TECHNOLOGY

ELECTRONICS INDUSTRY MUST MAINTAIN QUALITY CONTROL

Tokyo NIKKEI ELECTRONICS in Japanese No 262, 13 Apr 81 p 252

[Article by Katsutaro Kataoka, president of Alps Electronics Company]

[Text] Production Scale of Electronics Industry in the Next 10 Years....

I think this industry is highly favored. A transceiver boom which was triggered by the oil shock was followed by a tremendously vigorous growth in microcomputers. At the same time, VTR [Video Tape Recording] began to stand up. As a result, the electronics industry showed a growth rate of 25 percent in 1980 and the 1981 growth rate, too, is expected to be of the order of 15 percent. Although it is very difficult to make a guess further ahead, home computerization, computer application to household appliances and special terminal facilities are expected to become very popular in the foreseeable future. Moreover, invasion by electronics in those traditionally mechanical devices such as cameras, business machines and automobiles has only begun. Taking all these into consideration, I feel that the electronics industry can very well grow in 10 years to twice today's size.

Electronic Parts Export in the Future....

The export situations are quite different with general electronic parts and with semiconductor parts. In case of general electronic parts, the prediction that "Southeast Asia with Japan at the center will become the supply base for the world's household appliance parts" has come true. This situation probably will not change for the next 10 years. However, the number of manufacturers of household electronic devices in the West is decreasing so that we are losing our trading partners there. Therefore, as far as general electronic parts are concerned, no trade friction will develop as a result of increased export.

General Parts Manufacturing Plant Export....

In order to avoid friction, approximately 50 percent of added values must be left at the spot. The majority of the major set manufacturers have already laid foundations for the on-site production, and even the parts manufacturing plants, especially the standard parts manufacturing plants and automated plants, will be exported in the future. However, it is impossible to prepare on-site the great variety of parts manufactured in Japan.

On-site Production in Cooperation With the West....

There have been many requests. But we have so far declined all. Because, there is too great a discrepancy in the social structure and management concept. I myself have organized a number of cooperative ventures in the past with some success and some failure. Based on my own experience, I would say it won't work.

Possibility of Maintaining High Reliability and Quality in the Future....

Once, there was a word "inspection" in Japan but the word "quality control" was missing from its vocabulary. We learned the word from the United States. That same United States has gone wrong. The one, to whom we had approached with humility in order to be taught, has now reversed the role. This is such a tremendous difference. However, it is a great mistake to think that now Japan is number one. They will definitely come back after learning the lesson. You can understand it very well if you only study history. However, I think it will take at least 10 years before they can catch up. Therefore, the 1980's are very important years to Japan. To begin with, Japanese politics and society must not let its people fall into an idle habit. The situations in West Germany in recent years provide a mirror for us to reflect upon.

The Number of Employees in the Future....

Necessary personnel will be added. A natural increase in the number of employees such as when a new business is established is quite all right. However, the per capita sales was 100,000 yen per month in the early 1930's and it was 1.42 million yen per month in 1980. This trend of growth is expected to remain unchanged.

Whether the Productivity Will Continue To Grow in the Future....

Automation is advancing at a tremendous pace. Measuring instruments and manufacturing equipment using microcomputers are increasing in number. Obsolete equipments are quickly rejected and replaced by new ones. From late last year to late this year, our company will invest 20 billion yen on equipment. On the other hand, the products are becoming smaller in size, lighter in weight, and thinner, and the added values have increased as a result of reduced material cost.

The Sales Scale in the Future....

The 1980 sales reached 145 billion yen and the future sales goal is tentatively set at 200 billion yen. We think this goal is definitely achievable by 1983 or 1984. Although we don't know what it is going to be like 10 years hence, the figures of future plans submitted by the heads of various business departments the other day added up to be 330 billion yen. We think this goal is achievable within 5 years.

The Scale of Research and Development Fund....

Out of a monthly sales of 12 billion yen 200 million yen are spent on research and development. It is a purely research and development fund and does not include expenditure for the establishment of a market. With a fund of this size something substantial can be done. Products which take a long time to develop often have a long life as well. Management ought to consider matters in terms of a 5-year cycle.

The Future Posture of Your Company and its Leading Products....

Probably not much change will take place during the next 5-year period. We will continue to work on those finished products based on the technology peculiar to our company. Speaking of finished products, we will no doubt consider adding semiconductor elements to the existing technology, such as special terminal machines referred to in the beginning. We would also like to manufacture ICs, but, of course, there is no use to start now. However, since ICs are indispensable in our finished products, we will get ourselves involved in the design of ICs and the design of their masks.

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SCIENCE AND TECHNOLOGY

ELECTRONICS INDUSTRY TO BE 10 TRILLION YEN INDUSTRY IN 1981

Tokyo NIKKEI ELECTRONICS in Japanese No 262, 13 Apr 81 pp 254-255

[Article by Shozo Watanabe, assistant editor]

[Texg] Gist: Due to the stable prices, the true personal income of the consumers and their desire to buy during 1981 will be greater than in 1980. The value of the yen will remain high, but not so high as to hurt the export competitive edge of Japan's electronics industry. Therefore, the demands here and abroad on the traditional household electric appliances centered around color TV will remain at an all time high level. VTR which grew at a redoubling pace during 1980 will continue to grow at a rapid pace during 1981 and its output is expected to surpass color TV. With the addition of video discs, the household electronic machines are expected to regain their growth power during 1981.

On the other hand, there exists a strong desire to invest in equipment inside industrial circles, and computers and measurement instruments are expected to show a continued high growth rate during 1981. However, communications equipment has reached a stable growth stage, while ME machines have begun to slow down, so that the relative weight of business electronic machines will decrease somewhat. The electronic parts will continue to grow at a brisk pace during 1981 thanks to the growth in various types of machines related to VTR and computers and the infiltration of many other areas by electronics. As a result, the production scale of Japan's electronics industry is expected to top 10 trillion yen.

In order to compile the 1981 perspective of Japan's electronics industry, NIKKEI ELECTRONICS as usual distributed the questionnaires to 207 departments of 95 domestic manufacturers of electronic machines and 163 departments of 86 companies responded. In addition to the data gathered from these questionnaires, we were assisted by the industrial investigation department of Japan Industrial Bank, the 1st and 2d industrial departments of the editorial bureau of NIPPON KEIZAI SHIMBUN and NIKKEI BUSINESS.

With a Growth Rate of Slightly Less Than 15 Percent, Gross Product To Top 10 Trillion Yen

The results obtained from compiling the responses to the questionnaires are as shown in Table 1. According to these data, the gross product of Japan's electronics industry during 1981 is expected to grow 14.7 percent over the

previous year and top over 10 trillion yen, reaching 10,588,600,000,000 yen. Although the 1981 growth rate will not equal that of the previous year of 23.4 percent (estimated), the domestic demand is expected to increase over the previous year while the export environment is not expected to worsen either. Therefore, Japan's electronics industry will probably show a high rate of growth 3 years in a row.

Household Electronic Machines Make a Comeback onto the High Growth Rate Line

All three departments including household electronic machines, industrial electric machines, and electronic parts grew together during 1980. The growth rate of the household electronic machines was the highest, amounting to 29 percent over the previous year. Export of the existing major machines such as color TVs, tape recorders, and stereo components by every manufacturer grew more than 30 percent, while domestic shipment of color TVs also set a historic high record. These contributed to the significant growth of domestic production. In addition, VTR grew at a redoubling pace compared with the previous year.

Namely, in addition to the smooth growth of the existing products, the growth of VTR contributed to the high rate of growth in 1980. The situations remain approximately the same in 1981. Although a significant growth in color TV is considered impossible, the high level of domestic demand will be maintained while export is expected to increase over the previous year. Approximately 80 percent of VTR products are exported, but the rate of popularization in Japan, the United States, and Western Europe is still today on the order of a single digit. However, true popularization will come in the future, and the demands here and abroad will be so high that the manufactures will not be able to produce enough equipment. The value of total VTR products in 1981 is expected to exceed that of color TV and occupy the largest share of the household electronic machines.

In 1981, new products such as video discs and digital audio discs will be added, and activities related to the development of the next large-scale merchandise such as VTR contained inside a camera will become more brisk. There is no longer a sense of saturatedness in the field of household electronic machines which was felt over the past several years. We might say that a strong growth power has been restored in the form of adding new merchandise to the traditional products which are growing steadily. As a result, this department is expected to grow 13.2 percent over the previous year to reach 3,652,700,000,000 yen during 1981. The composition ratio will be down 0.5 points from the previous year but will be up 1 point from 1979.

The Specific Weight of Industrial Electronic Machines Will Drop

The industrial electronic machine production is expected to grow 14.2 percent over the previous year to reach 3,715,400,000,000 yen during 1981. Computers and the related equipment are estimated to have grown 19.6 percent to reach 1,365,000,000,000 yen in 1980. A growth rate of nearly 20 percent is expected during 1981. The brand-new large-scale machines made public by various manufacturers of general purpose machines during the latter half of 1980 have picked up such a tremendous volume of order that a brisk market activity of these large-scale machines is expected during 1981.

On the other hand, in the area of computer export, personal computer export has been newly added to the traditional general-purpose OEM computer exported by the domestic machine manufacturers and the private company-brand computer export centered around the office computers, so that 1981 is going to be a year of export rush. Personal computers in particular are beginning to show a growth pattern characteristic of this export leadership type comparable to household products.

Supported by a strong desire to invest in equipment by the industrial circles, the measurement instruments are expected to continue growth at the same rate of 17.6 percent during 1981 as in the previous year. In the field of industrial instruments in particular, the electronics industrial circles have carryover orders in large numbers, so, although there exists some uncertainty in the export picture, production is expected to grow 20 percent over the previous year. In the field of measurement instruments, significant growth is expected to continue during 1981 in general and LSI testers in particular, thanks to aggressive investment in the equipment made by every semiconductor manufacturer.

In contrast, the domestic production of communications equipment will not see significant growth because of the difficulty encountered by the Nippon Telegraphy and Telephone Public Corporation in raising its materials fund and the effect of the open-door policy. The manufacturers are all at once switching over to the needs of the private sectors such as facsimile and information processing machines. The growth during 1981 in this field is expected to be a steady 8 percent. The ME machines which had shown a high rate of growth in the past several years began to show a slack recently and the growth rate is expected to drop significantly. As a result, the composition ratio of the industrial electronic machines will drop another 0.1 point in addition to a drop of 2.2 points in the previous year and become 35.1 percent.

Electronic Parts Will Continue To Sail Before the Wind

Electronic parts registered a record high growth rate of 25.9 percent in 1980 over the previous year. Increased demand on VTR, information processing machines, increased export, and the expanded market resulting from infiltration into various other fields by electronics, all contributed to expand the scale of electronic parts production. The production scale is expected to grow 17.1 percent over the previous year to 3.22 trillion yen during 1981. As a result, its composition ratio will increase 0.6 points over the previous year and become 30.4 percent.

Among the general electronic parts, the structural parts and magnetic tapes are expected to continue a high rate of growth. Although the IC department in general is also expected to sail before the wind during 1981, when the state of oversupply of MOS memory centered around the 16K RAM will be dissolved, it remains a source of concern. If the state of oversupply were to continue to the end of this year, the growth rate would have to be modified downward. However, industrial circles are planning to invest in equipment more this year than in the previous year considering that the oversupply is limited to the memory only. The trade friction surrounding the semiconductros is in a state of lull at the

moment, but there is sufficient danger of rekindling the conflict if a large volume of Japanese made 64K RAM were to pour into the U.S. market.

A Pivotal Year for the Future Development

During 1981, the domestic demand is expected to turn for the better while the export environment is expected not to worsen any more. Then, it is almost certain that Japan's electronics industry will go over the 10 trillion yen mark in products. It was in 1966, when mass production of color TVs was established, the production scale went over the 1 trillion yen mark. Since then, except for a few exceptions, we expanded the scale of our operation by the method of introducing a technology from abroad, improving it, then mass-producing it, and exporting more than 50 percent of the total product. A production scale of 10 trillion yen means that it can compete for the 1st or 2d place with the automotive industry (including parts) among all domestic machinery industries. It is also equivalent to approximately one-fourth of the total demand on electronic machines and parts of the three areas--United States, Western Europe, and Japan--combined. Expansion beyond this scale based only on the improvement of the existing products will probably be difficult to achieve, while new technologies that may be introduced from abroad are also growing relatively smaller in number. After all, the future expansion posture will probably have to be one of developing a new market with a product developed by our own power. VTR as a part of the household electronic machines is an excellent example. Standing on an industrial foundation valued at 10 trillion yen, 1981 may be reckoned as a pivotal year which marks a starting point for new development.

Table 1 Perspective of 1981 Japan's Electronics Industry (Unit: million yen)

表1 昭和56年度日本電子産業見通し（金額単位：100万円）

		(1) 54年度(実績) [構成比(%)]	(2) 55年度(推定) [構成比(%)]	(3) 56年度(予測) [構成比(%)]	(4) 55/54 年度(%)	(5) 56/55 年度(%)
(6)	民生用電子機器(合計)	2,501,237 [33.5]	3,226,800 [35.0]	3,652,700 [34.5]	129.0	113.2
(7)	(電子レンジを除く合計)	2,371,843	3,095,000	3,519,700	130.5	113.7
(8)	産業用電子機器(合計)	2,792,890 [37.4]	3,252,600 [35.2]	3,715,400 [35.1]	116.5	114.2
(9)	(電卓を除く合計)	2,600,947	3,038,100	3,494,400	116.8	115.0
(10)	コンピュータおよび関連装置	1,141,179	1,365,000	1,636,000	119.6	119.9
(11)	電子応用装置	178,248	214,300	245,000	120.2	114.3
(12)	医用電子装置	92,080	106,000	117,700	115.1	111.0
(13)	有線通信機器	571,000	622,700	664,100	112.3	108.0
(14)	無線通信機器	307,700	364,500	401,600	118.5	110.2
(15)	電気計測器	310,740	365,600	430,000	117.7	117.6
(16)	電卓	191,943	214,500	221,000	111.8	103.0
(17)	電子部品(合計)	2,183,239 [29.2]	2,749,430 [29.8]	3,220,520 [30.4]	125.9	117.1
(18)	有線通信機器部品	48,696	50,400	50,800	103.5	100.8
(19)	一般電子部品	1,148,554	1,427,200	1,655,900	124.3	116.0
(20)	電子管	310,320	373,380	415,420	120.3	111.3
(21)	半導体	257,290	297,450	329,500	115.6	110.8
	IC	418,379	601,000	768,900	143.6	127.9
(22)	合計	7,477,366	9,228,830	10,588,620	123.4	114.7
(23)	(電子レンジ, 電卓を除く合計)	7,156,025	8,882,530	10,234,620	124.1	115.2

KEY:

1. 1979 (actual results) [composition ratio (percent)]
2. 1980 (estimate) [composition ratio (percent)]
3. 1981 (projection) [composition ratio (percent)]
4. 1979/80 fiscal year (percent)
5. 1980/81 fiscal year (percent)
6. Household electronic machines (sum total)
7. Sum excluding electronic range
8. Industrial electronic machines (sum total)
9. Sum excluding electronic calculator
10. Computers and related equipment
11. Electronics-applied equipment
12. Medical electronic equipment
13. Wire communications equipment
14. Wireless communications equipment
15. Electric meters
16. Electronic calculators
17. Electronic parts (sum total)
18. Parts for wire communications equipment
19. General electronic parts
20. Electron tubes
21. Semiconductors
22. Sum total
23. Sum excluding electronic range and calculators

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CHALLENGE TO CONTINUOUS STEELMAKING

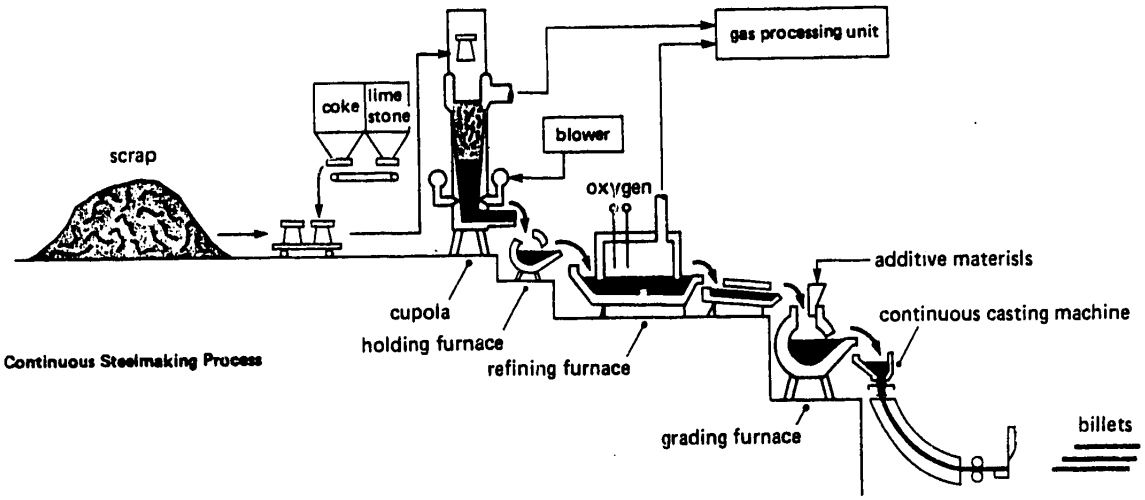
Tokyo DIAMOND'S INDUSTRIA in English Vol 11, No 5 May 81 pp 21-22

[Text]

On April 28, the ceremony to mark the inaugural blow-in of the cupola for a pilot plant for continuous steelmaking was held at the Tomakomai Works of Shimizu Steel Co. in the Tomakomai industrial complex now under construction. The pilot plant was built to carry out a research project for continuous steelmaking using car scrap steel, which was commissioned to Mitsubishi Heavy Industries in April, 1980, by the Research Development Corp. of Japan (JRDC). The term given for development is up to September, 1982. Facilities of the plant go into operation one by one, and full-scale test operations are expected to begin this summer. The steel production capacity of the pilot plant is 10,000 tons a month (scraps of about 25,000 passenger cars are to be used). The billets to be produced will be used to make steel bars by Shimizu Steel.

Basic research in this field of technology has been conducted since 1964 by the Metal Processing Division of the National Research Institute for Metals of the Science and Technology Agency (Division Director: Ryuichi Nakagawa, doctor of engineering). The main purpose of the research project is development of technology for continuous steelmaking for which industrialized countries are conducting researches on varied systems and none of them have developed a practical system. Today, steelmaking is practised by batch processing by a converter, an open-hearth furnance or an electric furnace. If the technology for continuous steelmaking was developed, an unmanned steel mill could become a reality. This, of course, would be an epoch-making development that would totally change the world's steelmaking system.

However, some countries have suspended research on the new system for technical, cost and other reasons. Japan is the only country that continues a large-scale research project. JRDC was established in July, 1961, with a government fund. It commissions development of new technologies to private institutions and manufacturers. The research on continuous steelmaking is a big project carrying



Continuous Steelmaking Process

an outlay of ¥1,359.6 million (approx. $6,500,000).

The continuous steelmaking system developed by the National Research Institure for Metals adopts a multi-staged system in which furnaces having different functions are connected continuously. Basic data were obtained through research by use of a mathematical model and a water-using model and then by an experimental plant capable of making 8 tons of steel per hour. Then a 15 tons per hour plant was built at the Hiroshima Shipyard & Engine Works of Mitsubishi Heavy Industries to obtain basic data for building a large pilot plant.

Now, the time has come for the construction of a pilot plant for industrial use. Mitsubishi built continuous casting facilities for Shimizu Steel in the past. This time, it built a pilot plant in the wide premises of Tomakomai Works of Shimizu Steel.

The plant consists of a cupola, a holding furnace, a refining furnace, a grading furnace and a continuous casting machine. Steel scraps, coke and lime stone are put in the cupola, and steel scraps are melted by the heat of coke flame. Molten pig iron flows out continuously from the cupola. It is desulphated and its quality is uniformed in the holding furnace. Molten pig iron is flown into the refining furnace at a given speed to be refined by blowing oxygen. In the grading furnace, materials are added to molten steel to adjust its contents. Molten steel is drawn as billets by the continuous casting machine.

In the new system, all major steelmaking processes are carried out in different furnaces. It is, therefore, easy to adopt a computer control system. All the furnaces are closed, and gases discharged by them are processed in a different facility. Since it is a continuous process, it does not produce a large amount of gas at a time. This means large-sized gas processing equipment is not needed. Nor are cranes to carry ladles. Therefore, the costs of plant and equipment are lower than those of conventional systems.

It also consumes less electric power, since its main fuel is coke. According to a projection, the new plant consumes 50 kWh to make a ton of steel,

compared with 450~500 kWh for the conventional electric furnace. The yield rate is 95% as against 88%~90% for the electric furnace. The new system requires 30 persons, while the electric furnace is manned by 50 workers.

Research on continuous steelmaking began to raise productivity and lower costs. But now the project is also aimed at conserving energy and natural resources and protecting the environment. And this process can serve the purposes. The new process can properly treat bulky car scraps, which contain large amounts of many kinds of materials and are shunned by steelmakers using electric furnaces. It can also use reduced iron. Since the cupola and the blast furnace have practically the same structure, though different in size, the continous steelmaking process can also apply to the blast furnace. The pilot plant may lead the steel industry to a great future.

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SCIENCE AND TECHNOLOGY

MARINE RESOURCE DEVELOPMENT TECHNOLOGY TO BE PROMOTED

Tokyo NIKKEI SANGYO SHIMBUN in Japanese 10,12,13,18,19,20 Feb 81

[Part 1, 10 Feb 81 p 13]

[Text] The ocean is said to be "the only frontier left on earth for mankind." However, on the one hand, its severe enviroment affected by rapidly changing weather conditions and pressure increases of 1 atmosphere for every 10 meters of depth has kept man from easily utilizing it. But, as land resources and energy are beginning to become limited, increasing interest has been shown in the ocean as the "treasure chest of resources." The United Nations Conference on the Law of the Sea that determines the new international order of the sea, has the prospect to arrive at a final consensus and signing of the Law of the Sea Treaty in September this year at the Caracas, Venezuela conference. Under such circumstances, a full-scale "ocean development era" is about to begin for the development of manganese nodules that lie in the deep seabed and the seabed petroleum of the continental shelves. We shall examine the future outlook by focusing on the current state of marine resources development.

Appearance of Shinkai

The biggest topic this year in Japanese marine development is the launching and beginning of submersion tests of the 2,000 km-class submersible ship "Shinkai 2000." Submersible ships are equivalent to spaceships in the space development program. The landing of the spaceship Apollo on the moon and the first lunar field survey by man enabled rapid progress in subsequent space development. Similarly, it is believed that the actual survey of the deep sea by researchers using submersibles will bring the solution of mysteries such as the production process of manganese nodules in the deep seabed one after another.

"Shinkai 2000" is 9.3 meters in length and weighs 24 tons. Three persons are on board, and the vehicle moves about at the depth of 2,000 meters along the sea bottom at a speed of 1 knot. The crew members can photograph seabed conditions using a television camera and sample seabed minerals using a manipulator. It is the 15th submersible in the world that can dive to a depth of 2,000 meters.

After conducting various tests, "Shinkai 2000" which was launched in January will begin test submersions at Ushiomisaki offshore at Wakayama Prefecture in about May, and work toward the goal of submerging to a depth of 2,000 meters in August. Thereafter, the ship is to be delivered by the manufacturer, Mitsubishi Heavy Industries, at the end of October to the owner, the Center for Marine Science and Technology. Full-scale surveys will begin in about 1983. It is expected to demonstrate its power in surveys of mineral resources such as manganese nodules, seabed petroleum in the deep sea area of the Japan Sea and natural gas reserves.

As if to respond to the new Japanese movement, the UN Conference on the Law of the Sea--in which the North and the South have continued to have disagreements for a long time--is expected to settle these problems during the year. The Law of the Sea Treaty to be signed at the Caracas conference will become the "constitution" for the future use of the world's oceans. A new international order of the sea that conforms to the structure of the international society of today will be decided concerning the territorial sea, the high seas, continental shelves, as well as the development of manganese nodules, prevention of ocean pollution, scientific surveys, etc. The treaty is an enormous document consisting of 320 main articles and 119 articles in the annexes totalling 439. Since ratification by 60 countries is conditional for the treaty to become effective, it is expected to take 6-8 years for it to demonstrate its actual effect.

Even though the effectuation is 6 years ahead, the fact that a new order of the sea has been agreed upon is likely to further accelerate the ocean [resource] development of various countries in the world. In order to store independent technological forces in Japan, the government will embark on a comprehensive marine technological development program beginning in JFY 1981. In particular, the policy is to proceed on four fronts: 1) ocean surveys which involve detailed exploration of the deep seabeds adjacent to Japan and in the Pacific Ocean, 2) resources development such as developing manganese nodules, 3) research and development of ocean energy such as wave power generation, ocean thermal energy conversion, etc. and 4) utilization of space above the sea.

Exploitation of the Continental Shelves

In order to obtain petroleum, natural gas, or manganese nodules from the sea, the project includes exploitation of continental shelves at a depth of approximately 200 meters and the deep seabed of several thousand meters in depth. First of all, continental shelves produce petroleum and natural gas. The 200-mile area of the Japanese economic zone is estimated to be approximately 4.51 million square kilometers. This area is 12 times the land area of Japan and the 6th largest in the world.

In this area, petroleum development is believed to be feasible in the near future in the 280,000 square kilometers continental shelves at a depth of less than 200 kilometers, and their sloped areas of 480,000 square kilometers making a total area of 76,000 square kilometers. The recoverable reserves of petroleum and natural gas in these continental shelves are estimated to be 1.3 billion kiloliters. Especially in the East China Sea area, 60 percent of the total petroleum and natural gas is estimated to occur.

In order to establish the technology to recover such petroleum and natural gas, the development of a "seabed petroleum production system" began in 1978 as a large-scale project of the Agency of Industrial Science and Technology, MITI. In order to recover petroleum from a deep oil field at the great depth of 300 meters or more, this system employs a new method to transport oil or gas from the seabed to the surface with jointed pipelines. A comprehensive ocean experiment of this system is scheduled in JFY 1983 at a depth of approximately 50 meters.

Along with oil and natural gas, what is even more eagerly looked forward to is the manganese nodules. Unlike oil and natural gas that form layers deep in the seabed, manganese nodules occur on the deep sea floor like gravel at a depth of 3,000-6,000 meters. Beside manganese which is indispensable for iron manufacturing, they contain useful metals such as nickel which increases steel alloy strength, copper used for electrical products, and cobalt used in special parts. The amount of the resource is said to range from 1 trillion tons to 1.7 trillion tons in the Pacific Ocean alone, and it is looked forward to as the "last common resource of man."

In particular, cobalt is also used as a heat-resistant material in jet engines and is an important strategic resource. However, cobalt producing countries are concentrated in politically unstable areas such as Zaire in Africa. The aircraft manufacturer Lockheed and others organized an international consortium and are engaged in the development of manganese nodules. It is rumored that their goal is to secure strategic resources such as cobalt and nickel. Cobalt is also a precious material for magnetic tapes, and it is a metal that is of great interest to Japan.

While joining, in part, such a movement with the United States, Japan, a resource-poor country, has embarked on the survey and technical development of manganese nodules as a national project. The Metal Mining Agency of Japan will strengthen the survey of manganese resources off Hawaii with Daini Hakuryo Maru in 1981, and riding on the large-scale project of the Agency of Industrial Science and Technology, it finally decided to embark on the development of "manganese nodule recovery technology."

Opening of an Era of International Competition

However the sore spot of the ocean technology program such as described is that existing land technology cannot be applied directly. In order to ensure stable conditions even in rough seas under bad weather conditions, it is necessary to begin with basic research and steadily accumulate technology. In addition, a system tends to become gigantic which often entails a development risk. For these reasons, development at the national scale is inevitable.

The United States employs an international joint venture system by means of joint investment of private corporations and is energetically advancing the development of manganese nodules. Will Japan be able to accumulate the technological force in her government-civil structure to compete with the Euro-American force and reach the practical application? Ocean development is rapidly shifting from infancy to an era of vigorous international competition.

[Part 2, 12 Feb 81 p 14]

[Text] Seabed Petroleum Production System

Seabed oil fields are said to be the last petroleum resource left for mankind. The development of technology to upwell the oil efficiently and stably from the bottom of the sea has become an extremely important element that affects international power relationships. Competition to develop seabed oil fields in shallow waters of about 100 meters in depth has already passed the peak technologically, and the focus has shifted to the development of oil fields on continental shelves and slopes at a depth of 300 meters or more.

Research With National Efforts

Various advanced countries which are pressed with energy demands, not to mention the major oil companies, are engaged in technical research for oil field development in deep seas using their entire national efforts. Beyond the depth of 300 meters, conventional technology for seabed oil field is not sufficient. A new technological breakthrough is necessary.

The Royal Dutch Shell oil field in the Gulf of Mexico is pumping oil from the deepest sea at present. The depth is 312 meters. This is said to be the economically profitable limit for the conventional method of building a tall scaffold called a jacket from the sea floor and drilling a well. At any rate, this jacket which was completed in 1977 is approximately 380 meters high including the portion above the water. It is taller than Tokyo Tower by as much as 50 meters. Since the construction period is also long, unless it is an oil field of fairly big scale, the venture does not make sense on a commercial base.

In fact, if it involves only the drilling of a well, present technology can carry it out at a deeper level. Drilling has been successful on the seabed 1,055 meters in depth offshore Thailand by Exxon, 1,325 meters in depth offshore Congo by Getty, and 1,499 meters in depth offshore New Foundland by Texaco. The problem is the system of "oil production" in pumping the oil in a stable way from the well and bringing it up to the surface.

Japan Establishes a Research Laboratory

Japan fell behind Euro-American countries in land oil production technology, and wishing to rank with the world in a seabed petroleum production system, the agency of Industrial Science and Technology of MITI initiated a large-scale project in 1978. It is a research association, Seabed Petroleum Production System Research Laboratory (abbr. SPS Research Laboratory).

A total of 18 firms are gathered in this Laboratory: 5 petroleum development firms including Arabian Oil Co., Ltd. and Idemitsu Petroleum Development; 1 petroleum engineering company, 10 iron manufacturing, shipbuilding, and heavy machinery companies including Nippon Steel Corp. and Mitsui Shipbuilding, and 2 electric appliance manufacturers including Tokyo Shibaura Electric.

The managing director, K. Yamamura proudly states: "It is the first attempt to contend with petroleum development with the combined Japanese technological force. The potentials of the participating firms are fairly high, and we should be able to compete squarely with Euro-American countries."

The goal of the SPS Research Laboratory is to operate systems equipment installed on the sea floor and do away with gigantic ocean structures such as a jacket. Their target is to develop seabed oil fields at depths of 200-900 meters. A system to produce seabed petroleum without using a jacket is employed by some concerns as a supplemental system to the jacket method in the North Sea oil fields of the Garoupa oil field off Brazil, but a full-scale system has not been completed as yet.

The system research department chief, S. Inoue of the above research laboratory, from Arabia Petroleum Co, states: "The technology for producing oil from a deep-seabed has a complexity equivalent to space development, and it demands reliability. Projects for development extend to many areas such as the development of material that endures hydraulic pressure and sea water corrosion, technology to accurately install large, complex equipment on the dark sea floor at a certain position, a computer system to control the above equipment, a sensor that quickly detects abnormalities, technology for maintenance and inspection by remote control, etc. It may be said that 'the ripple effect to other fields is that much greater.'"

In addition, supposing that the area of development is in the sea adjacent to Japan, the relationship with the fisheries industry and effects on the environment must also be taken into consideration. To avoid tangling with fishing nets, the protruding parts of the well and pipelines must all be buried into the seabed, and oil leakage must be strictly monitored for environmental safety.

Applicable Even in Drift Ice Region

The attractiveness of a seabed petroleum production system without using a jacket is not limited to seabed oil field development at great depths alone. Since all equipment is placed on the sea bottom, the system is useable in oil field development in a region of icebergs or drift ice. Moreover, the construction period is shorter by as much as a year and a half to 2 years, and the construction cost is less than half. Taking advantage of these merits, there is a concept of applying them to the development of small and medium-size oil fields in a shallow sea.

From the viewpoint of early recovery of invested capital, one way is to use the system to convert an experimental well directly into a producing well as a stop-gap measure until a full-scale jacket is constructed. Mr Yamamura states "feasibility for the practical use of a system developed for the deep sea is higher in shallow seas."

U.S. firms such as Cameron and Vetco that work exclusively with petroleum production systems also have already invested considerable capital into such research. However, enveloped in a secret veil equivalent to military technology, its actual state is not revealed. In a field where important technological information does not flow at all, the possibilities for technical agreement are scarce, and the only way is to make ones technological breakthrough independently.

[Part 3, 13 Feb 81 p 13]

[Text] A seabed petroleum production system is said to require four subsystems. The first is the wellhead system. It is the part that collects several tens of different valves that adjust the pressure and flow rate of the oil that ascends from the oil pool as much as 2,500 meters below the surface of the sea floor. Because of the valves sticking out like tree branches, it is commonly called a Christmas tree.

The second is the manifold system. It is a relay base to deliver oil coming from the wellhead to the sea surface. The assembly includes electric and hydraulic control systems. The third is the pipeline system. It conducts oil from several wellheads scattered on the sea floor to a manifold. It connects directly to a land system when the site is near land. The fourth is the riser-storage system. It consists of a riser that conducts oil perpendicularly to the sea surface from the seabed 300 meters or deeper, and a storage tank to receive it.

Wellhead Has a Cover

Every subsystem has a hitch in the respective development. The wellhead system will be buried in the seabed so that fishing boats may operate above it, and a smooth cover is placed over the wellhead. To this end, the Christmas tree having numerous protrusions must be made compact into an assembly like a single pipe. Moreover, the valves must endure a high pressure of 350 kg per square centimeter and be highly reliable to enable accurate operation by remote control from above water for them to be meaningful.

In addition, to prepare against an accident that may occur by any chance, a "re-entry" mechanism must be built in that can open the wellhead cover from above the surface with a system hung on a wire and make repairs. It is also necessary to provide a device for secondary recovery that extracts the remaining oil by forcing water into the oil pool after the natural flow stops. If one considers the premise that the well operates for over 20 years, these are the minimum essential requirements.

The manifold is a seabed base so to speak. Men will go down occasionally for inspection work. For this reason, a service capsule is required to send men to the manifold from the ship on the surface. In the plan made by the SPS Research Laboratory, the capacity of the capsule is four persons. Three workers will be dispatched into the manifold.

During that time, the work area in the manifold will be filled with air to enable the workers to operate without the use of diving units. This is called "a dry system" and is in practical use in part at the Garoupa oil field off Brazil. At a seabed of more than 300 meters in depth, a wet system using divers for work is inefficient.

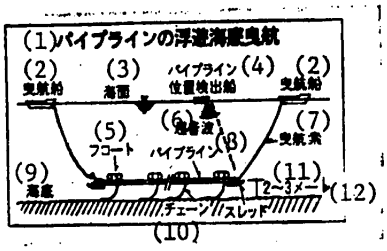
Jointed Riser Conducts Oil

The problem point of the riser-storage system is how to conduct oil perpendicularly into a storage tank floating on the sea surface 300 meters above. The

ocean entails waves and currents, and a hard piece of pipe has a good chance of being broken by their forces. Therefore, a jointed riser is being considered. The idea is to eliminate the effects of waves and currents as wind in a willow tree by using so-called universal joints in two places on the riser and for connecting it to the storage tank.

With the pipeline system, the technology for installation is the first problem. The pipeline to be buried into the seabed will measure nearly 2 meters in diameter when it contains powerlines, communication cables, etc. Since divers cannot be used, it is assembled on the ground in a fixed length, towed with a boat, and dropped accurately onto the predetermined site.

A pipeline measuring as long as 2 km cannot be towed practically on the surface to transport it to the construction site from the land. There is also a chance that the pipeline may be damaged by the wave resistance. Thus, the concept of seabed float-towing technique was born (see diagram). The pipeline is suspended at a level of 2-3 meters above the surface of the sea floor and towed slowly by two towing boats. Another ship for detecting the pipeline position will cruise along in parallel, and the pipeline is laid with precise positioning using ultrasonic waves.



Key:
(1) Seabed Float-Towing of Pipeline
(2) towing boat
(3) sea surface
(4) pipeline position detector ship
(5) float
(6) ultrasonic wave
(7) towing line
(8) pipeline
(9) sea floor
(10) chain
(11) sled
(12) 2-3 meters

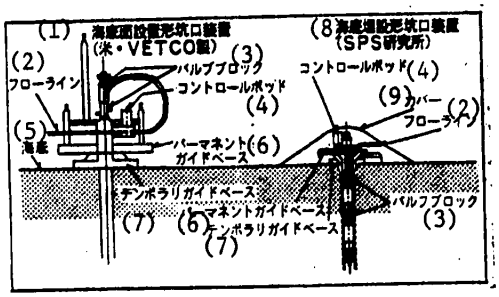
Connection Is the Most Difficult Part

This does not mean all the problems have been solved. Next, the pipeline has to be connected to the wellhead system and manifold. And, it is a tough job. Both ends of the pipeline are equipped with flexible tubings. They are laid down with the ends slightly bent, and the wellhead and manifold connect the pipeline by drawing it from both sides.

At SPS Research Laboratory, each system is being developed separately by the participating firms. For the most difficult technical development of systems connection, the mutual exchange of information is essential. Managing director Murayama states "work is going smoothly with the mutual exchange of information even in the area marginal to the knowhow of the individual firms." An intercorporate connection system is apparently perfect as well.

Flexible tubings are apparently being developed by a French firm, Coflexip, but the product is not available, and the tubing is being independently redesigned. The material for the wire to lower the reentry system was also newly developed.

The system of precision positioning, riser, etc are expected to have a considerable spinoff effect on marine development in general such as ocean energy application and the development of manganese nodules. Research and development officer, S. Yokoyama, of the Agency of Industrial Science and Technology states "leaving the spinoff effect for individual firms to consider, we have just finished a detailed plan for each system, and have begun test manufacturing equipment heading for a 1983 comprehensive ocean experiment. It is a time to demonstrate whether we can compete on equal terms with Euro-American counterparts having an enormous accumulation of technology."



Key:

(1) Seabed Installation Type Wellhead (manufactured by VETCO, U.S.A.)
(2) flowline
(3) valve block
(4) control pod
(5) sea floor
(6) permanent guide base
(7) temporary guide base
(8) Seabed Embedding Type Wellhead System (SPS Research Lab)
(9) cover

[Part 4, 18 Feb 81 p 16]

[Text] Manganese Nodules

Among the resource treasures in the ocean, what stirs the vision of research and development workers in particular is the manganese nodules that lie in the deep sea of 5,000 meters. Manganese nodules which are said to be "the mass of important metals" contain nickel, copper, cobalt, etc several hundreds to several thousands fold the land reserves in the area of the Pacific Ocean alone. Being labeled as "the strategic resource of the 21st century," worldwide interest is steadily increasing. There is now a prospect to conclude the dispute of the International Law of the Sea, and various Euro-American countries are getting ready to begin at any time not only in the basic technological aspect, but also in the legal aspect. Japan will also make full use of the manganese nodule prospecting ship, Daini Hakuryo Maru from JFY 1980, while starting a national project led by the Agency of Industrial Science and Technology from JFY 1981 and challenge commercialization in the 1990's along with various Euro-American countries.

Opposition Between the Developing Countries and the West

Manganese nodules were discovered more than a century ago. Prospecting activities mainly by the Euro-American countries began energetically in the 1960's. Today, it is estimated that 400 billion tons of manganese, an equivalent of 300 fold the land mine reserves is deposited in the Pacific Ocean alone. In addition, nickel amounting to 16.4 billion tons, copper amounting to 88 billion tons, and cobalt amounting to 98 billion tons are estimated: all with richness of a different level from the land reserves. Moreover, for these metals Japan depends nearly 100 percent on imports. While resource nationalism is beginning to gather strength, the knowhow to secure the seabed manganese nodules has became a matter of great concern not only for Japan with poor mineral resources, but for all the industrially advanced countries.

Developing countries are similarly keeping their eyes on the manganese nodules in the seabed. If advanced countries begin randomly digging at will, a "manganese war" may well develop not only among the advanced countries, but between the East and the West, and the North and the South as well. For this reason, the United Nations decided in 1970 that manganese nodules, one of the deep-seabed resources, are the "common property of mankind," and had been deliberating a legal system concerning their development since 1973 at the International Conference on the Law of the Sea.

The issue of deep-seabed resources development centered on manganese nodules was placed as an equally important topic as part of general Law of the Sea problems to be deliberated, such as territorial sea and economic zones, as well as ocean pollution prevention and scientific research. The major advanced countries in the Western hemisphere and Japan strongly assert the system of returning part of the profit obtained from development to the international society with the viewpoint that "the development should be carried out mainly by government or private firms." The international authority to be established based on the treaty took the stand that activities by government or private firms should not be unreasonably restricted.

Opposing this, the developing countries, with the strength of their overwhelming majority, maintain that the international authority should play the central role in development based on the recognition of "common property of mankind." The following circumstances apparently exist as a backdrop: 1) the countries that have nonferrous metal land resources are mainly developing countries, and they are concerned about the price drop of the resources they own as a result of seabed resource development; and 2) while the advanced countries have been preparing a developmental structure early, the developing countries without funds and technology wish to participate in the development themselves by securing funds, technology, and mining claims by some means.

Submission of a Mining Claim and Revenue-Sharing System

The major points which have been considered at the Law of the Sea conferences thus far include: (1) establishing at the United Nations the International Seabed Authority and an international organization to engage in development (Enterprise); (2) an advanced country can secure a mining claim she prospected in

exchange for an equivalent mining area; (3) advanced countries must transfer technology to the Enterprise and developing countries, and at the same time, must pay part of the revenue to the authority; and (4) as a result, countries without technology and financial means with respect to prospecting and mining, are not authorized development rights.....etc.

The UN Law of the Sea Conferences that dragged on with the North and the South in vigorous opposition is at last expected to consolidate a reasonable framework at the 10th session to be opened in New York this spring and bring about the signing of the treaty by various nations at the Caracas conference in September. Naturally, it is expected to take 7-8 years before it becomes effective through ratification by each nation, and the date for commercialization of manganese nodules together with prospecting, mining, research on refining technology for practical use, is likely to be in the 1990's.

Japan has participated in the deliberations thus far along with the advanced countries. However, some view that "there is a technical gap of 5-10 years in ocean development compared to Euro-American countries." Thus, the Conference on the Law of the Sea that dragged on because of resistance by developing countries allowed Japan, in a sense, "the best chance to buy time." Particularly, in order to secure the right to participate in the development stipulated "to require accumulation of technology," it is essential to carry out research and development with a national effort in the future.

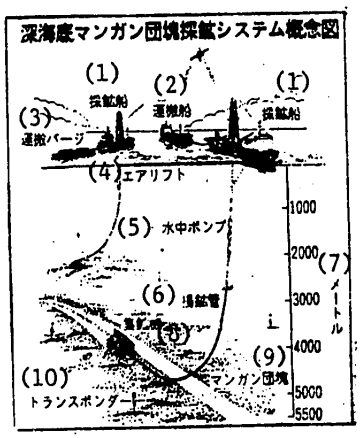
Maiden Voyage to Offshore Hawaii

Thus, Japan opted for a large-scale project to develop a "manganese nodules mining system" with the concentrated effort of civil and government organizations. Based on accumulated basic research by the National Research Institute for Pollution and Resources of the Agency for Industrial Science and Technology and survey and research by a corporate aggregate, the Deep-Seabed Mineral Resources Development Association organized by the Metal Mining Agency of Japan and related firms, Japan has set the target for establishing the world's leading technology for practical use in a concerted effort during the 7 years beginning in JFY 1981 with a total investment of 22 billion yen.

Currently a basic plan is being devised urgently led by the Agency of Natural Resources and Energy and the Agency of Industrial Science and Technology. They plan to establish a receiving organ for development by recruiting participant firms and to set up a definite schedule for activities ranging from a conceptual plan to elemental technology development, a detailed plan, system trial manufacturing, and overall experiment and evaluation in the ocean.

Prior to the start of the large-scale project, the first Japanese prospecting ship exclusively for manganese nodules has also begun operating. "Daini Hakuryo Maru" (gross tonnage in excess of 2,000 tons, service speed of 15 knots, and cruising range of 12,000 nautical miles) was completed in May last year, and its first full-scale prospecting which began in July was completed after 6 months. While "Hakuryo Maru" which was carrying out basic research previously has been a multi-purpose ship in charge of geological surveys in general, the "Daini Hakuryo Maru" is equipped with the newest equipment such as navigation system, an echo sounding prospecting device, DTV (deep-sea television), sample

collector, on-board data processing unit, etc, and is capable of operating 250 days annually. The exploratory ability was upgraded 5-6 fold. In her maiden voyage to the southern offshore of Hawaii, she had already "obtained a considerable response" (Agency of Natural Resources and Energy).



Conceptual Diagram of Deep Sea-bed Manganese Nodule Mining System

Key:
(1) mining ship
(2) carrier
(3) carrier barge
(4) airlift
(5) underwater pump
(6) mineral lifter pipe
(7) meters
(8) mineral collector
(9) manganese nodules
(10) transponder

[Part 5, 19 Feb 81 p 16]

[Text] In contrast to Japan whose developing structure had finally taken form, the steps taken by the Euro-American countries indicated their very quick recognition of manganese nodules as "important strategic military material." In the United States, a government survey was made in the 1960's, and in the 1970's, major capitalists such as U.S. Steel, INCO, Kennecott, and Lockheed formed international consortia one after another. West Germany, France, and Russia are also advancing prospecting activities with a concerted national effort, and at the same time, they have worked desperately for a long time to accumulate mining technology.

The United States as Well as Germany and France Show Achievements

In 1978, the U.S. Steel group succeeded in a mineral lifting test of 50 tons/hr with an airlift method. The INCO group also realized in the same year a total lifted volume of 800 tons by combining an airlift and pumping method. The Kennecott group accumulated model experiments for each elemental technology such as mineral collector, lifting pump, mining technology, etc and is said to be planning a comprehensive ocean experiment at approximately half practical scale. The Lockheed group continued with scale model experiments until the

early 1970's, but began mining experiments in 1978. In each group, it appears that "prospecting has almost been completed" (K. Takada, deputy head, Dept. of Nickel and Heavy Metals, Mitsubishi Shoji), and some have arrived to take application procedures for mining claims to the government.

In West Germany, the prominent mining companies, Metallgesellschaft, Preussag, and a 100 percent government-funded national enterprise, Salzgitter, formed a joint enterprise, AMR, in 1974. In addition to keeping up with prospecting activities, it also joined the INCO group with a 25 percent share, and have achieved a deep-sea test of a mineral collector in 1976 and a deep-sea mining experiment in 1978.

Meanwhile, in France who holds New Caledonia, the so-called treasure chest of nickel, the National Ocean Exploitation Center, Atomic Energy Agency, Geological Survey Institute, SLN, a nickel firm indirectly funded by the government, and a private firm, Dunkirk Shipbuilding, established the "AFERNOD (French Nodules Research and Development Association)" in 1974. Using four prospecting ships, they have reportedly discovered thus far as much as 150,000 square meters of promising areas centered around off-shore Hawaii and Tahiti. Mining is also being promoted using several methods in parallel and small-scale model experiments and conceptual designs for comprehensive experimental systems are being advanced.

In addition, they have decided to spur development for practical purposes as a national project from 1981 investing a total of 30 billion yen in 8 years following the basic research carried out thus far. Their policy is reportedly to dissolve AERNOD gradually by the end of 1981, to establish a special corporation for development and to expand and strengthen the structure for prospecting and technical development combining the civil effort.

"Check Ball" for the Developing Countries

It may be said that the development of manganese nodules has approached the stage of "ready for the real show any time" for the Euro-American countries with accumulated technologies which are said to be "5-10 years ahead of Japan" (Agency of Natural Resources and Energy). In that sense, the fact that deliberation of the Law of the Sea, which includes ruling on the international order of manganese mining, dragged on due to resistance by developing countries may have appeared as a "shelving" and went beyond the limit of patience.

Consequently, a noticeable trend in the Western countries is to legislate a domestic law to endow a legal foundation for developmental activities during the provisional period until the Law of the Sea takes effect. First of all, the United States and West Germany legislated in succession a domestic law for the development of seabed resources last year. England and France are said to be preparing to do the same. All of them aim at independent prospecting in the deep-seabed which is in the high seas and to prepare for a fighting structure toward the commercialization of manganese nodules. They may be interpreted as a kind of check ball against the developing countries who are dragging out the settlement. In order to line up with the group of advanced countries, there are

voices apparently that urge legislation of a domestic law in Japan also, and the government in part has started to examine the issue.

Needless to say, Japan has not been idle, either. Since JFY 1975, MITI has conducted surveys for 90 days annually concerning the state of manganese nodule distribution using the geological survey ship "Harkuryo Maru" centered around the southern offshore of Hawaii. Full-scale exploration began in JFY 1980 on 250 days a year with "Daini Hakuryo Maru" which has a capability 5-6 times that of its predecessor.

In JFY 1974, the Metal Mining Agency of Japan began the development of prospecting equipment. A highlighted item is a deep-sea high-speed television system (DTV) that accurately sees the 6,000-meter deep seabed where no light reaches. It boasts a world's leading function in that it transmits the seabed image to the mothership while being towed by maintaining a height of approximately 3 meters above the sea floor and concurrently the distribution rate of the manganese nodules is instantly measured and recorded by a shipboard computer. It is currently on board the "Daini Hakuryo Maru" and is beginning to demonstrate its power. At the same time, a subsystem to obtain an accurate position of the towed body is also being studied concurrently, and it is anxiously awaited with an expectation of doubling the DTV power in JFY 1981.

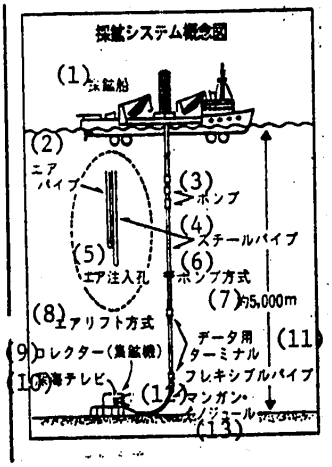
"Mixed Blood Group" and "Pure Blood Group"

Meanwhile, approximately 40 private firms in the industrial circles of trading, mining, shipbuilding, heavy machinery, electric machinery, transportation, etc organized an aggregate corporation, Deep-Seabed Mineral Resource Development Association (DOMA) in 1974 and have begun studying elemental technology related to mining and the total system in addition to analyses of domestic and overseas technical information and surveys on environmental effects. Last year, they newly established the "Department of Resources Survey," and approximately 30 researchers sent from the participant firms are assigned to be engaged full time in the survey work throughout the year. In order to efficiently arrange, analyze, and keep the enormous data obtained by the manganese nodule distribution survey, a prospecting data analysis system making the full use of computers is expected to begin operation soon at the Metal Mining Agency of Japan.

Among the influential plutocratic corporations, each group en bloc joined an international corsortium and is busy acquiring the leading technology. Japan Deep-sea Mining Corp [Nihon Shinkai Kogyo] organized by 23 firms of Sumitomo group invested 25 percent in the INCO group along with the United States, Canada, and West Germany. With an investment of 40 million dollars for development, mining technology experiment with a pipe system and one called the CLB system using a bucket have been accumulated. Participation in development is not only by investment, but technical participation by the Japanese are also notable. A mineral collector independently developed by Sumitomo group corporations such as Sumitomo Metal Mining Co and others has been employed in a series of experiments.

The Mitsubishi group including Mitsubishi Shoji, Mitsubishi Heavy Industry, Mitsubishi Metal Mining, etc, joined the Kennecott group with a 10 percent share. They secured more than two promising mining claims by rough prospecting thus far, and have also succeeded in developing a highly energy-saving wet process refining technology using ammonia. Thus, they developed a way for ocean refining which is said to greatly influence the future economy of deep-seabed manganese development.

The 13 Mitsui group corporations led by Nippon Steel Corporation and Mitsui & Co. did not join an international consortium, but formed a domestic joint development organization. Basic technologies have been accumulated by holding periodic research meetings and by collaboration with the DOMA. In short, the "mixed blood group" that joined the international consortia and the "pure blood group" such as the Mitsui group are set to promote the large-scale project as bitter enemies in the same boat. What will the technological issues and economic outlook be...?



Conceptual Diagram of a Mining System

Key:
(1) mining ship
(2) air pipe
(3) pumps
(4) steel pipes
(5) air injection port
(6) pump method
(7) approximately 5,000 meters
(8) air lift method
(9) collector (mineral collector)
(10) deep-sea TV
(11) data terminal
(12) flexible tubing
(13) manganese nodules

[Part 6, 20 Feb 81 p 18]

[Text] It is said that the technical development of the ocean is very difficult. Although we can land men on the lunar surface 380,000 kilometers away, underwater work at a depth of more than 300 meters cannot be done at will. Although we can draw very large-scale integrated patterns with one micron precision, vessels on

the Pacific Ocean cannot be confirmed within 100-meter error. This is due to unique restrictive conditions of the ocean.

More Difficulties To Overcome Than in Space

For example, in space, the pressure difference from the earth surface is 1 atmosphere anywhere, but in the ocean, 1 atmosphere is added for every 10 meters of depth. At a depth of 5,000 meters, it is 500 atmospheric pressure. Only those materials that can withstand that pressure are useful. In contrast to space where orbit can be estimated, there is no law regarding the behavior of submerged objects. Furthermore, while electric waves travel well in space, attenuation in the sea is too severe, and we must rely on sound waves. The distance and speed of propagation are drastically small, and it is also affected by water temperature and density. Light reaches only about 10 meters, and the need for a propulsion force which is minimal in space, is considerable in the sea. However, unlike the atmosphere where attenuation is minimal, we cannot send high voltage into the sea.

These manganese nodules at the bottom of the sea are troublesome stuff. At any rate, they are difficult to obtain since they are distributed lightly in two-dimensional fashion on the deep-seabed of as deep as 5,000 meters. For commercial production, it is said that approximately 3 million tons (dry weight) should be mined per year. To attain this goal, mining must be done by quickly moving over the very extensive sea floor. Assuming that the scan/recovery efficiency of the mineral collector is 25 percent, and manganese nodules occur at 10 kilograms per 1 square meter, the collector must be operated in an area as extensive as 1,700 square meters per year. Since underwater conditions are constantly changing, there is considerable misgivings concerning economic loss due to uneven mining.

It it were a land mine, machinery for mining, transportation, ventilation, dressing, etc can be systematically joined from the working face to the pit-mouth, to the dressing plant. For instance, when ores are mined in excess of transportation capacity, they can be temporarily stored, and the "unification" required of each piece of equipment is relatively relaxed. Maximum capacity can be readily pursued in individual equipment, and perfect automation is not necessary.

On the contrary, strict control is required in the case of the seabed manganese mining, where the subsystems in charge of mining, transportation, etc are directly coupled using only one lifting tube. The biggest issue is to insure reliability of the system as a whole. In the deep sea of 5,000 meters, first, repairs and inspections by men or submersible are impossible. Once breakdown occurs, the entire system is stopped, and it would take at least 10 days to draw up lifting pipe as long as 6,000 meters, restore, and recast the mineral collector. This is a fatal blow for commercialization, and it is necessary, as a rule, to secure completely maintenance-free underwater equipment and a low failure rate that enables at least 2-year continuous operation.

Systems Remote Control

The large-scale project to be launched in JFY 1981 by the government and civil sectors is, in short, a challenge for high reliability. The first item is the remote control technique for the overall system. In the case of the mineral collector, not only the controls of position, direction, and attitude, but avoidance of obstacles and the quantity of nodules taken in must be controlled. In addition, during lifting, the flow rate, attitude, and stress of the pump must be controlled, and clogging by nodules must be carefully monitored. During mining, it is necessary to control the support of the mineral lifting pipe, position, speed, and direction of the mothership in cooperation with underwater equipment.

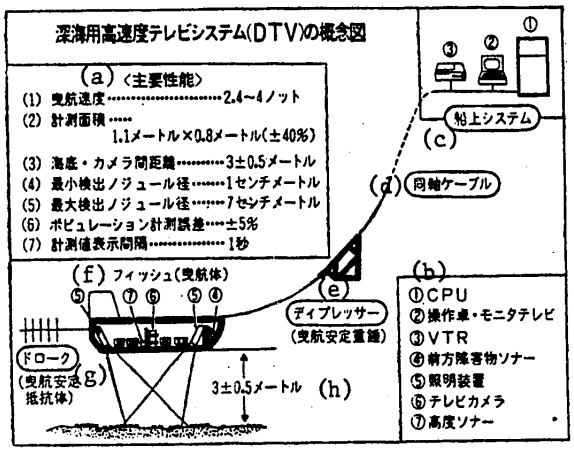
Ready-made products cannot be directly used in the case of individual elemental technologies, either. First, one must consider how to lift manganese nodules mixed with water and muddy sand from a depth of 5,000 meters. In the past, mineral slurries were mostly transported horizontally, and practically no case of vertical transportation existed. In addition, the size of the solid granules are irregular, and the tubings also swing about in the sea. Consideration must be given not only to increase the strength and pressure-enduring properties of the tubing itself, but to the flow speed and concentration distribution of the nodules within the tubing.

The underwater power system to be used for the mineral collector and lifting pump is also a source of concern. An oil- or water-sealed pressure balancing motor will be used, but a drastic improvement is necessary to make it a large-scale, high voltage motor. The Japanese achievement for underwater motors thus far is bearly 400 kilowatts or so, and a voltage as high as 3,000 kilowatts is required for mineral lifting. At the same time, underwater transmission technology also needs to be developed. Thus, terminal equipment such as connectors will be re-examined from scratch.

The handling system for the underwater equipment will have a far greater capacity and complicated function compared to those generally used for off-shore oil drilling. For example, the support load is approximately 150 tons in the case of oil drilling, but it is 1,000 tons for manganese mining, and the attaching and detaching of tubing must be converted from manual to automatic process. When this system is compared to the Daigo Hakuryu Maru to be used in offshore oil drilling, the difficulties involved include: the maximum operable depth is more than 10-fold greater, the plant installation is not fixed, but self-propelled, and in order to stop the system for an emergency, utmost care must be given lest it will not restart.

Recovery of Capital Is Also Questionable

After breaking through such technological problems, how do we fair economically? According to the 1978 reply of the Oceanographic Development Council, an advisory organ of the Prime Minister's Office, the policy is "to enable production of 70,000 tons of pure nickel from manganese nodules in 1990." The price of nickel is currently about 2 million yen/ton, resulting in an annual revenue of roughly 140 billion yen. However, "the world's annual production is about



Conceptual Diagram of Deep-Sea High Speed Television System (DTV)

Key:

(a) Major Particulars

(1) towing speed.....2.4-4 knots
(2) measuring area.....1.1 m x 0.8 m (±40 percent)
(3) sea floor-camera distance.....3±0.5 m
(4) minimum detectable size of nodules....1 cm
(5) maximum detectable size of nodules....7 cm
(6) population measurement error....±5 percent
(7) measured value display interval....1 sec

(b)
(1) CPU
(2) operation console-monitoring television
(3) VTR
(4) forward obstacle sonar
(5) illumination system
(6) television camera
(7) height sonar

(c) shipboard system
(d) coaxial cable
(e) depressor (weight to stabilize towing)
(f) fish (towed body)
(g) drag (drag to stabilize towing)
(h) 3±0.5 m

100,000 tons at the most" (Manganese Nodule Team leader of Mitsui & Co, K. Yagyu, deputy head of the Nonferrous Metal Department), and if the "developmental cost is at least 200 billion yen" (same source as above) per 1 unit of plant, one cannot always envision a rosy economy.

Also, in the case of cobalt, assuming that the seabed manganese nodules will supply 10 percent of the current production of 23,000 tons in the world, the revenue is 30 billion yen at most. Since "'promising mining lots' covering approximately 100,000 square kilometers are limited in number to about 5" (Manganese Nodule Project Team leader of Mitsubishi Shoji, K. Takada, deputy head of Nickel Heavy Metal Department), even if we prospect and secure by hard work an area approximately half the size of Japan, including the lot for submission to the Authority (international authority), recovery of the invested capital is very uncertain.

Reflecting such circumstances, the idea being emphasized is that "we should not only conserve transportation costs by refining the minerals on the mothership, but also combine it with an exclusive self-sufficient energy system such as by ocean thermal energy conversion using a depth of 5,000 meters" (J. Hasegawa, chief, Ocean Resources Department, Sumitomo Metal and Mining). To that end, it may be necessary to venture in a form of "national project with concerted national efforts" (Yagyu) as well as a "'world consortium association' that further unifies the existing international consortia" (Hasegawa).

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MEL-LASER CHALLENGES A 20-KW OUTPUT

Tokyo DIAMOND'S INDUSTRIA in English Vol 11, No 5 May 81 pp 22-23

[Text]

In February, 1981, the Agency of Industrial Science and Technology of the Ministry of International Trade and Industry designated Mitsubishi Electric Corp. as the main contractor for the research and development of a high-power laser system to be used for the national R&D project, "Flexible Mfg. System Complex Provided with Laser." This project has been undertaken since fiscal 1977 (April, 1977~March, 1978) under a 7-year plan with a budget of roughly ¥12,000 million. The research on the high-power laser system was originally entrusted to Toshiba Corp. and Mitsubishi Electric Corp., which have separately produced on a trial basis CO_2-gas laser systems with an output of 5 kW. The Agency of Industrial Science and Technology, which has been examining the two companies' systems since last autumn, made a decision in favor of Mitsubishi Electric Corp. The company now challenges to develop a system with an output of 20 kW.

The systems worked out by the two companies are equal in that the output of 5 kW can be obtained continuously. Each equipment has a reserver of CO_2-gas, which is circulated through the laser tube. In order to increase the efficiency of laser beam generation, the equipment is of the transverse type, meaning that the direction of the laser beam crosses the flow of CO_2-gas at right angles. The product of Mitsubishi Electric is of the three-axis type and the direction of electric discharge for excitation crosses the above-mentioned two directions at right angles. But the product of Toshiba is of the two-axis type, in which the direction of electric discharge coincides with that of gas flow.

And the product of Mitsubishi Electric uses greater gas pressure. This means that equipment with a large output can be made compact. Thus the system of Mitsubishi Electric was adopted for producing equipment with the output of 20 kW. Naturally, both systems have merits and demerits. Part of Toshiba's excitation system is to be used. The two companies are scheduled to cooperate in producing a 20-kW equipment on an experimental basis.

Since laser beam can be concentrated into a thin beam, it can make processing of substance accurately.

When the laser beam strikes a substance, it can cut, weld and harden the substance with heat, but the place around the part being processed is little affected. Cutting by the laser beam does not create powdery waste as an ordinary cutter does. It does not make noise, either. Since laser beam has such merits, it is thought to be a major method of processing in the future and the use of it has been adopted in the foregoing national R&D project. It is thought that the use of CO_2-gas laser is the most suited to the purpose of attaining a large output.

Japan is said to be about five years behind the United States and European countries in the research on laser beam. Japan has only developed the above 5-kW CO_2-gas laser equipment. Avco Everett Research Laboratory Inc., a subsidiary of Avco Corp., is selling 15-kW CO_2-gas laser equipment. One equipment was delivered to the Welding Laboratory of Osaka University in 1980 through the trading house, Marubeni Corp. This is the largest laser system existing in Japan.

However, it is only in recent years that the laser systems have been put to practical use. It is said that 30 to 40 units each with an output of 1 kW, have been put to practical use in the United States. Mitsubishi Electric produces units ranging in output from 1 kW to 3 kW, and sells mainly 1 kW units under the brand name of MEL-LASER. The company's shipment in 1980 was about 10 units, all for research purposes. Although units with the small output have already been put to practical use in Japan, those with larger output are going to be used from now on.

Mitsubishi Electric began research on CO_2-gas laser in 1967, three years after the United States developed the first equipment. And the company succeeded in the commercial production of 1-kW units in 1977 for the first time in Japan. The company now aims at commercial production of 5-kW units developed under the foregoing national project. If sanctioned by the Ministry of International Trade and Industry, the company plans to start their production and sales in 1982. By the way, the 20-kW equipment to be developed under the project is to be completed in September, 1983.

In Japan semi-conductor laser is used widely for optical communications. Since the mass production of video disc players has started, He-Ne laser equipment is also being mass-produced. The production of laser scalpels has also begun. The days are coming when Japan will become one of the most advanced countries in laser technology as well as electronics. The day will not be so distant when CO_2-gas laser equipment with a large output can be put to practical use.

CSO: 4120/235

SCIENCE AND TECHNOLOGY

DETAILS GIVEN ON GEKKO XII MODULE GLASS LASER SYSTEM

Amplification Properties

Osaka LASER KENKYU [REVIEW OF LASER ENGINEERING] in Japanese Vol 9, No 1, Jan 81 pp 31-37

[Report on research on amplification properties of the laser system by Junji Kuroda, Yoshiaki Kato, Kunio Yoshida and Chiyoe Yamanaka of Osaka University Institute of Laser Engineering]

[Text] 1. Introduction

The success or failure of nuclear fusion power reactors will depend on the size of the Q value, which is ratio of energy from the fusion reaction to the input energy. In laser fusion the Q value is the coefficient of laser energy; it is estimated that about 200 kJ of laser energy is necessary to reach the break-even point (Q=1). In 1980 the Osaka University Institute of Laser Engineering began to build GEKKO XII, a glass laser system with output energy of 20 kJ and a peak output of 40 TW, as an energy driver to bring about a plasma state which meets the Lawson conditions for reaching the break-even point. For the previous 3 years, 1977-1979, we had worked to develop the GEKKO XII module system (hereafter called GM-II) and to develop the technology necessary for the GEKKO XII system. It was thus possible to clarify the technology of both the constituent laser elements and the overall system, and to bring about capabilities and reliability far in excess of earlier glass laser devices. This paper is the first of a series of papers on this GM-II development.

2. GEKKO XII Module Development Program

Glass laser devices with output energy in the range of 10kJ can be roughly divided into those with a few large-aperture beams and those with many small-aperture beams. The SHIVA device of the Livermore Laboratory (University of California) is representative of the first group, and the DELFIN device of the Lebedev Institute (Soviet Union) and the OMEGA device of the University of Rochester are examples of the second group. Giving consideration to ease of use, cost and future expansion, we decided on a few large-aperture beams as the basic mode for the GEKKO XII device, and the emphasis of the GM-II Development Program was on development and evaluation of the technology necessary for that. The SHIVA has an output aperture of 20 cm, 20 beams, Nd:silicate glass as the active medium,

output energy of 15kJ (pulse width 1 ns), and peak output of 30 TW (pulse width 100 ps). However, we had already verified with the GEKKO IV device that using Nd: phosphate glass it is possible to obtain a peak output of 1 TW with an output aperture of 11 cm.[1] Thus in GM-II, Nd: phosphate glass was used with a maximum amplifier aperture of 20 cm. There is the problem in an Nd: phosphate glass laser that the possibility of parasitic oscillation with the laser glass increases with the cross-sectional area of induced emission.

But it was shown during the development of GM-II that in the laser glass we used there was no parasitic oscillation even in the largest diameter amplifier. This meant that full use could be made of the special characteristics of Nd: phosphate glass, which has the advantage of a small nonlinear optical constant and is advantageous even at a diameter of 20 cm.

The GM-II development plan can be roughly divided into four stages. In the first stage the major components used in GM-II were tested and evaluated for reliability of performance. During this time the technology for manufacture, inspection and handling of the large-diameter optical elements was developed. This technology was used in the second stage for planning, manufacture and testing of whole components. In the third stage the laser portion of the GM-II device was set up, the amplifier train was evaluated, and preliminary testing of the automatic alignment system was carried out. And finally, in the fourth stage the whole device, including the target illumination section, was designed and comprehensive testing was carried out by means of computer control. This development process brought many successes in terms of improving the performance and reliability of the large-scale laser glass device. The details of these results are to be published in a series of reports, of which this paper is the first. This paper concerns the results of testing of laser amplification characteristics which was carried out in the third stage. An unusually high peak output value of 3.4 TW was obtained with a pulse width of 100 ps; amplification saturation characteristics were found to vary with the type of laser glass at a pulse width of 1 ns, so we will report these results here.

3. Laser Amplification Chain

Figure 1 shows the optical arrangement of the GEKKO XII module's laser portion and target illumination section. The laser portion comprises the preamplification chain (X-chain) and the main amplification chains (Y-chain and Z-chain). The output laser beam enters the target chamber after being reflected twice by flat mirrors. These devices were set up in a clean-room (class 1000) measuring 12 m x 48 m. Each component was attached to an optical bench fixed over vibration-free flooring, or to a steel-framed optical truss. Dust covers were attached between components, thus preventing dust on the optical elements or disruption of the laser beam by air movement. Although not indicated in Figure 1, photoelectric devices for automatic alignment and gauges for monitoring laser operation were attached. The control section and the power source were contained in separate rooms: all operations were by remote control.

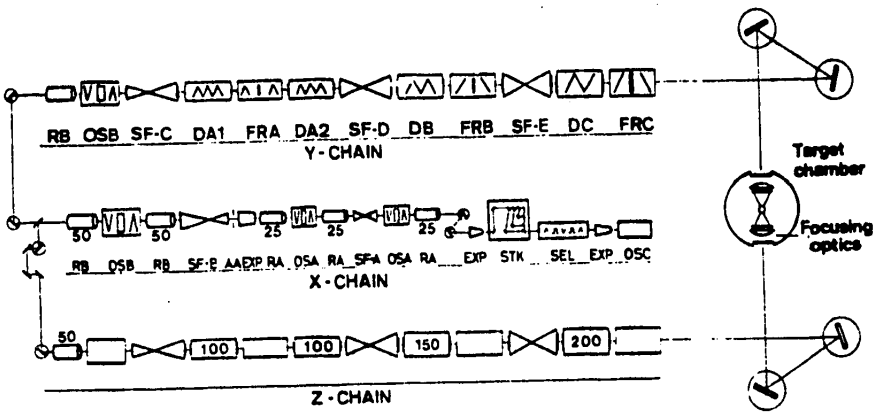

Figure 1. Optical Arrangement of GEKKO XII Module

OSC: oscillator
EXP: expander
SEL: pulse selector
STK: pulse stacker
RA, RB: rod amplifiers
DA, DB, DC: disk amplifiers
OSA, OSB: optical shutters
SF-A--SF-E: spatial filters
FRA--FRC: Faraday rotators
AA: hard aperture

The oscillator is a forced mode synchronous oscillator using Nd: YAG[2] (repetition rate 5 Hz), and an oscillation line of 1.052 μm is obtained by inserting a compound refraction filter into the resonator. Following pulse extraction and synthesis, the beam diameter is expanded to 22 mm (one-thousandth diameter at peak strength with Gaussian distribution), and amplified with a rod amplifier (RA) with an aperture of 25 mm. The RA small signal gain is a maximum of 59-fold, as shown in Table 1. The end surface of the laser glass, perpendicular to the axis of radiation, has an antireflection coating and the three RA stages are optically isolated by optical shutters (Pockls Cells) and vacuum spatial filters, so there is no parasitic oscillation. After the amplified laser beam is expanded threefold to 66 mm, an aperture (AA) is used to keep the central 10.5 mm. Image transmission of the intensity distribution at the surface of the aperture is accomplished using spatial filters SF-B through SF-E, as shown in Figure 2, and spatially unbalanced expansion of the intensity distribution is prevented through use of Fresnel diffraction.[3] Table 2 shows the specifications of spatial filter input and output lenses and the diameters of pinholes used, as stated below, in amplification testing. The laser diameter of the beam which has passed through the aperture is expanded to 44 mm by SF-B and amplified in three stages with 50 mm diameter rod amplifiers (RB). Next the beam is expanded to 94 mm by SF-C and amplified by disk amplifiers (DA 1, DA 2) to 100 mm in diameter. There are optical glass windows perpendicular to the beam axis on the input and output sides of all disk amplifiers which prevent dust from entering the amplifiers and damaging the surface of the disk glass. The laser beam is further expanded and amplified to 141 mm, and then to a final output beam with a diameter of 190 mm. Faraday rotators (FR-A through FR-C) are used to block transmitted light from reflected beams or other beams on the target.

Table 1. Amplifier Specifications and Performance

	Laser glass	Lamps		Input energy (kJ)	Measured axial small signal gain
RA	25[1] - 380[1] 1.2% doping	15[1]bore 300[1]arc	6	22.5	59
RB	50[1] - 380[1] 0.6% doping		6	22.5	13.4
DA	214-114-24[t]-6 2.9% doping	15[1]bore 1270[1]arc	16	220	8.5
DB	325-184-30[t]-4 2% doping		24	330	3.4
DC	400-214-32[t]-3 1.9% doping		32	440	3.2

Table 2. Spatial Filter Lens Specifications and Pinhole Sizes Used for Amplification Testings. D is the aperture and f is the focusing length of the lenses

	Input lens		Output lens		Pinhole sizes	
	D (mm^4)	f (mm)	D (mm^4)	f (mm)	100 ps (μm)	1 ns (μm)
SF-A	56	1000	56	1000	300	300
SF-B	56	800	56	3200	1500	2500
SF-C	56	978	110	2088	400	600
SF-D	110	1200	152	1800	400	400
SF-E	152	1278	200	1722	400	400

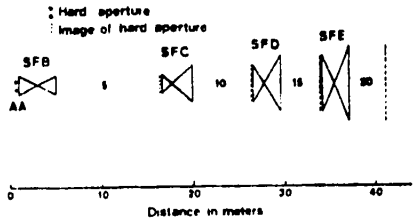

Figure 2. Relay Imaging of a Hard Aperture (AA) Using Spatial Filter Optics

The optics used in this device have controlled surface precision; all, including large-diameter laser glasses and dielectric polarizers, have a flatness within $\lambda/8$ (λ = 6328Å). Because of the uniformity of the optical materials, transmission wave-front aberration of the optical elements used for transmission is, with the exception of certain laser glasses (the RB rod glasses), within $\lambda/5$. All optical surfaces perpendicular to the beam axis (rod glasses, disk amplifier windows, spatial filter windows, target illumination elements, etc) are coated to prevent reflection (reflection reduced to less than 0.1 percent). Laser beam impairment by these antireflection and reflective coatings, vaporized onto surfaces like the dielectric multilayer film polarizer, was tested using a sample treated by the same process; values in excess of 4.9 J/cm^2 were confirmed using a pulse width of 0.1 ns. The elements making up the Faraday rotators and amplifiers were washed and assembled in a class 100 clean-room, then sealed with dust covers and taken into the laser room, where optical surfaces received periodic inspections. There were no macroscopic scratches or dust in the path of the laser beam.

The Nd:phosphate glass used in this device was LHG-7 in the X-chain and Y-chain and LHG-8 in the Z-chain (made by Hoya Glass Works). The DB in the Z-chain was, however, LHG-7. As shown in Table 1, measurement of the amplification characteristics of these laser glasses shows a 3.2-fold small signal gain in the 200mm diameter disk amplifier. For this coefficient of gain, $\alpha = 0.10^{-1}$ and $\alpha D = 4.0$ (the length of the disk glass is D = 40 cm). This value had been assumed achievable when complete edge cladding is used (when an absorbent material is used around the edge of the disk glass to prevent parasitic oscillation), and the performance of solid cladding used with LHG-7 and LHG-8 was shown to be good. The 150 mm diameter disk glass is large and its gain relatively small because the amplifier was built to be water-cooled and it was used for tests with a high rate of repetition; this effect will be discussed on a separate occasion.

4. Measurement of Amplification Properties

Measurement of the amplification properties of the laser amplification chain described above was done under the following conditions with pulse widths of 100 ps and 1 ns. The amplifier pulse was a simple pulse which had not passed through a pulse synthesizer (STK) and was almost exactly Gaussian in waveform; for reasons of convenience of installation, the measurement was made without the final Faraday Rotator (FRC). While varying amplification in the preamplification chain to change laser beam input energy to the main amplification chains and maintaining amplification in the main chains at a given level, we measured the output energy and the spatial intensity distribution. The beam self-focusing effect was a problem with the pulse width of 100 ps, so focusable energy was checked by using a streak camera to measure the laser beam which passed through a pinhole placed at a distance. Fluorescence was measured with the same arrangement. Measurements with the pulse width at 100 ps were made only on the Y-chain, but measurements at 1 ns were made on both the Y-chain and the Z-chain to check differences in the saturation effect. The pulse width of the laser beam was measured with a streak camera using a portion of the oscillator output. Pulse width stability was within ±10 percent (measurement threshold), and oscillator output stability was within ±5 percent. The calorimeters used

to measure laser beam energy were the Hadron Co Model 102 (for input energy) and the Apollo Co Model ACM-100 (output energy). The sensitivity of these calorimeters was checked with other calorimeters, and confirmed accurate within 10 percent.

4.1 Amplification Properties at 100 ps Pulse Width

In Figure 3, Y-chain output energy with a pulse width of 100 ps (±10 ps) is plotted as a function of Y-chain input energy. In these measurements the amplifier small signal gain values used were about 30 percent below the values shown in Table 1. An input energy of 261 mJ yielded the maximum output energy of 346 J, or a peak output of 3.46 TW (±0.3 TW). It is possible that greater output could be obtained by increasing the input energy or by increasing the gain, but this value was taken as the maximum in these measurements out of consideration for the safety of the optical elements. To measure spatial intensity distribution, we focused the output laser beam with a lens having a focal length of 4 meters and recorded it on photographic film (Polaroid Type 55) placed 3 m from the lens. Two beam splitters (using surface reflection from flat glass plates) and a colored glass filter were placed in the path of the beam to attenuate laser beam energy. The resultant intensity distributions were not perfect near field patterns, but were confirmed separately as nearly so. Figure 4 shows spatial intensity distributions with output energy levels of 169 J and 346 J. There was almost no change in the intensity distribution when the output energy was increased, but Figure 4 shows that slight self-focusing had begun where intensity was greatest in the 346 J pattern. The ratio of peak to average in the spatial intensity distribution was 1.8 at 169 J and 2.2 at 346 J. On the whole, the intensity distributions are quite uniform, but there is still a ring structure; this results from the diffraction effect in the X-chain. It may be possible to increase output energy by improving that and making the intensity distribution even more uniform.

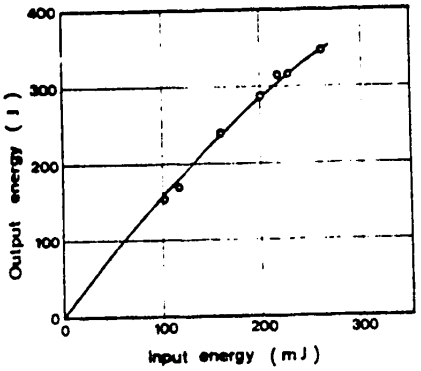

Figure 3. Amplification Property of the Y-Chain at 100 ps. Solid line is an empirical fit to the data points.

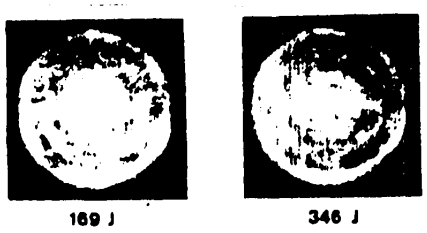

Figure 4. Near Field Patterns of the Output Laser Beam at the Energies of 169J and 346J Respectively. Off-centered ring-shaped interference patterns and small irregular noises are due to imperfections of optical attenuators used to take these patterns.

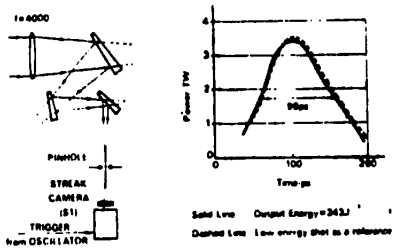

Figure 5. Experimental Setup (left) for Measuring the Focusable Power of the Output Laser Beam, and the Data (right) Obtained as an Output of the Streak Camera

Time changes in the far field pattern were measured using the arrangement in Figure 5 to investigate whether output energy could be focused on the target. A 600 μm diameter pinhole was placed at the focal point of a lens with a focal length of 4 m; this corresponds to 82μm for the target illumination lens with a focal length of 550 mm (f/2.7). The size of the far field pattern measured in advance using the setup in Figure 5 was about 240 μm (diameter of a circle enclosing 90 percent of laser energy). The curve shown in Figure 5 indicates the changeover time of the intensity of the laser beam passing through the pinhole; the dashed line is a reference line at low energy against which the vertical axis is standardized. As Figure 5 shows, the changeover time with an output power of 343 J is the same as at low energy, and the drop in intensity near the peak as the angle of divergence increases, seen when the self-focusing effect is strong,[4] was not observed. In short, the output of this laser is power which can be focused on the target.

The single-beam arrangement of the SHIVA device mentioned in paragraph 2 is about the same as GM-II, but its safe operation limit is about 1 TW at a pulse width of 90 ps; at 1.5 TW self-focusing causes a ratio of about 8 between peak and average in the spatial distribution of intensity, a distribution far less uniform than shown by the data in Figure 4.[5] Thus when a single-beam comparison is made, the output of GM-II can be rated at about three times that of SHIVA. This may result from the fact that the use of Nd:phosphate glass in GM-II makes it possible to operate with unusually high gain, and from the fact that dust and noise sources of optical elements which cause uneven distribution of intensity are minimized to the lowest possible level by means of a strict control of optical equipment.

4.2 Amplification Properties at 1 ns Pulse Width

Measurements with a pulse width of 1 ns were carried out in the same manner as at 100 ps. In this case, however, peak energy was low and self-convergence was not a problem, so only output energy and the near field pattern were measured. Within the energy limits measured, the near field pattern was almost the same as the low energy shot at 100 ps. Figure 6 shows output energy as a function of input energy for the Y-chain and the Z-chain. Different curves correspond to different levels of pumping energy; even where pumping low energy is the greatest (the uppermost Y-chain curve), the small signal gains are 20 percent

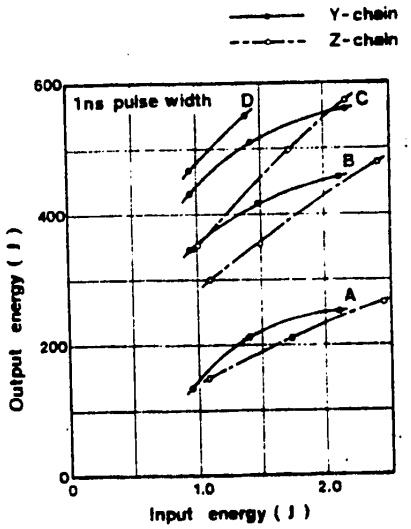

Figure 6. Amplification Property of the Y-Chain (—•—) and Z-Chain (--o--) for 1 ns. Each curve corresponds to different level of pumping energy.

(DC) or 30 percent (DA) lower than the maximum gains shown in Table 1. Measurement of the Y-chain and Z-chain were made independently, but stopped at about 570 J in both cases. The reason is that this corresponds to an average energy density of about 1.8 J/cm^2; when the ratio between peak and average intensity is 1.8, peak energy density is 3.3 J/cm^2, which is close to the critical limit for breakdown of the dielectric. Hereafter uniformity of the spatial intensity distribution is to be provided to enable high energy shots.

A point to be noted in Figure 6 is that there is a great difference in amplification properties between the Y-chain, which uses LHG-7, and the Z-chain, which uses LHG-8. LHG-7 saturates more quickly, and thus the saturation parameter is smaller. This data will be analyzed in the next paper, but the Z-chain data agrees better with the second-rank saturation model. The spectroscopic qualities of LHG-7 and LHG-8 are nearly the same; such items as the cross-sectional area of induced emission and spectrum width agree within 3 percent. It is thus hard to imagine that the saturation parameters of the two differ greatly. Nevertheless, the measured saturation parameters are largely dependent on the type of laser glass; there is also a report that this is related to unevenness in spectral spreading.[6] It will thus be necessary to give detailed study to the saturation characteristics of laser glass.

4.3 Other Characteristics

Fluorescent energy on target was measured using the arrangement in Figure 5 and operating only the amplification chains; a value of 9μJ was obtained. This value would be halved by the final Faraday rotator. There was no systematic

measurement of laser output stability, but it is within about 8 percent. Oscillator stability is extremely good and the charging voltage of the amplifier is regulated to within 0.1 percent, so it is anticipated that higher stability can be obtained. The repetition rate of laser devices is determined by the cooling time of the laser glasses; when this device is operated at 30-minute intervals, thermal distortion causes the spatial distribution of the laser beam to lose uniformity after four or five repetitions. When it is operated at 45-minute intervals this does not happen, so regular operation is possible.

The results of the above measurements are summarized in Table 3.

Table 3. Summary of the Amplification Property Testings of GEKKO XII Module

Parameter	Measured performance
Output energy	346J/100 ps, 567 J/1 ns
Focusable power	3.46 TW
Pulse width	90 ps - 1 ns
Energy reproducibility	±8 percent
Beam divergence	60 μrad
Amplified spontaneous emission	9 μJ (without FR-C)
Repetition rate	45 min

5. The GEKKO XII Module glass laser device, which has a 20 cm output aperture diameter and uses Nd:phosphate glass, has been completed. We measured its amplification properties and determined that a peak output of 3.46 TW, which is focusable energy, can be obtained when the pulse width is 100 ps. This value is about three times that of the SHIVA device, which has the same diameter aperture but uses Nd:silicate glass. We are testing amplification with a pulse width of 1 ns, and have obtained a maximum output of 567 J so far. It will be possible to increase output energy by improving spatial intensity distribution. This amplification testing also measured saturation properties of amplification, differences in which are thought to arise from different grades of laser glass. The reason for the differences is unclear at present, and will require more detailed study.

The above measurements were of the properties of the laser component; overall capabilities, including the target illumination device, and proposed improvements will be discussed in the next paper.

The GEKKO XII module device was developed with the cooperation of all personnel of the Osaka University Institute of Laser Engineering.

Finally, we wish to thank Teruo Yakuo, Tadao Moribe, Jusaku Komatsu and Hiroshi Imoto of Nippon Electric Co, for their cooperation in the measurement of amplification properties.

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Performance Evaluation

Osaka LASER KENKYU [REVIEW OF LASER ENGINEERING] in Japanese Vol 9, No 1, Jan 81, pp 38-45

[Report on evaluation of laser system performance by Junji Kuroda and Yoshiaki Kato]

[Text] 1. Introduction

In the preceding paper[1] (hereafter called I) we published the results of measurement of the amplification properties of the GEKKO XII Module Glass Laser (hereafter called GM-II), and reported that we had obtained a peak output of 3.46 TW with a pulse width of 100 ps, and output energy of 567 J with a pulse width of 1 ns. As stated in I, this data is not final, and it will be possible to obtain even higher output with the present device. When operating a laser system in this high energy region, it is necessary to have adequate understanding of the system's operating characteristics, and to know in advance which part of the system is the weakest in order to prevent breakdown. Through this sort of analysis, it is possible to establish operating conditions for the system, and to improve and upgrade the system by focusing on the weakest part.

With that object in mind, we developed a simulation code for glass laser system simulation. This code follows, in terms of time and space, the course which the laser pulse follows through the amplifier system, and uses approximation measures at a number of points; it is an extremely useful code if these approximations are taken into account. In this paper we will first state the outlines of this simulation code. We will then consider the values of parameters derived through use of this code in comparison with the measured values of GM-II amplification properties. We will also explain the limiting factors in use of GM-II in high energy regions, and propose a number of improvements.

We will then look into the maximum output energy and target illumination rate of the present device and those possible with the proposed improvements, and compare the strong and weak points of the present and proposed devices.

2. Simulation Code for Analysis of Glass Laser System

A number of features should be considered when a model is made of a glass laser system. First, the distance from the oscillator to the target is unusually long (about 100 m), and a number of optical elements are incorporated between the two. The laser beam is propagated in parallel rays as the diameter of the beam is increased by beam expanders or spatial filters. The diffraction which accompanies free propagation can be controlled through image transmission using the optics of a spatial filter.[2] Wave-front disruption due to diffraction from optical noise sources like dust or scratches in the path of the beam, or to uneven refraction patterns from the optical elements, cause irregular intensity distributions; these are difficult to control. Mirrors and polarizers are passive optical elements, but in many cases there are polarity characteristics in relation to transmittance and phase. Uneven temperature distributions in rod amplifiers (often along the axis of symmetry) cause internal stresses which result in multiple refraction. For these reasons it is not always possible to rely on straight-line polarization. Amplification by Nd:glass is normally expressed by a rate equation of the second order, and the saturation parameter is about 3 J/cm^2, so the saturation characteristics of amplification are important, especially with long pulse operations. When laser beams are propagated through optical materials, nonlinear refraction gives rise to an intensity-dependent wave-front lag, which causes small-scale self-focusing[3,4] and whole-beam self-focusing. The former can be eliminated by use of spatial filters, but the latter, because of the low-frequency component, passes through the filter and converges on the target, causing a shift of the focal point which is dependent on the intensity of the laser beam.[5]

The ideal would be to take all the above factors into consideration and analyze laser beam propagation, then check the effect of space and time on intensity and polarity at arbitrary points. But this is not realistic in terms of calculation time and precision. We will therefore simplify the problem by assuming radial symmetry (this is proper when there are no irregular noise sources) and ignoring the diffraction effect. We will not look into the precise distribution of spatial unevenness of intensity caused by self-focusing, but will find the degree of self-focusing by calculating the B value (described below) which expresses the extent of wave-front lag. As the B value increases, small-scale filamentation and the angle of divergence of the laser beam also increase, so the transmittance of spatial filters depends on the B value. Using these assumptions it is possible to quickly determine the effects of space and time on laser beam intensity. Since the results can be used as a close approximation, they will serve for system analysis and design. We will now give an outline of the code, and discuss limits of application and measures to be taken.

2.1 Outline of Code

2.1.1 Input Parameters

The properties of individual elements and the starting laser beam intensity $I(r,t) = I_p \cdot f(r) \cdot g(t)$ are provided as input parameters. In this expression, $f(r)$ and $g(t)$ are functions of radius direction coordinate r and time t, generally expressed by the following super-Gaussian distribution:

$$F(x) = \exp\ (-c|x - d|^e) \quad \text{(where c, d and e are constants)}$$

2.1.2 Output Parameters

The following parameters which characterize the laser beam are taken for the calculated output; 1) and 4) below are geometric expressions; the others are numerical.

1) laser beam wave form $I(r,t)$ and peak intensity $I_p(r_p,t_p)$

2) laser energy $E = 2\pi \int_0^R \int_0^T I(r,t)\ rdrdt$

3) fill factor $f = 2\pi \int_0^R I(r,t)\ rdr/\pi r^2 Ip$ where time is determined

by $t = t_p$ and $t = T_M(T_M + T/2)$. This is because $t_p \neq T_M$ because of wave form changes. The f expresses the proportion between average intensity (spatial) and peak intensity.

4) state of polarization $S(r) = (S_0, S_1, S_2, S_3)$

degree of polarization $P = \{(S_1^2 + S_2^2 + S_3^2)/S_0^2\}^{1/2}$

(Vector S is a Stokes quaternary vector.)

5) B value $$B(r,t) = \frac{2\pi}{\lambda} \cdot \frac{n_2}{n_0} \cdot \int_0^L I(r,t,z)\,dz$$

(where λ is the wavelength of the beam and n_0 and n_2 are the linear and nonlinear refraction rates).

In expression 5, z is the distance along the direction of beam propagation, taking into account the internal reduction of intensity (1/n) and the lightpath increase ($\sqrt{1+1/n^2}$) in connection with the Brewster angle of incidence. This integral expresses (in radians) wave-front lag arising from nonlinear effects. Thus B_T, the wholebeam B integral, provides a standard for wholebeam self-focusing.[6] The B value also expresses the growth coefficient of electric field amplitude perturbation in the unstable space frequencies, and thus provides the degree of small-scale self-focusing. (Amplitude is, with regard to small signal input, multiplied by following propagation.) This space frequency is eliminated

as a high-frequency component by the spatial filters, so B_S (the small-scale B integral) is determined by setting the space frequency at 0 after each passage through a spatial filter. B_T is the sum of the B_S.

2.1.3 Calculations for Individual Elements

1) Amplifiers

Saturation gain is calculated using the Frantz-Nodvik formula[7] determined by a rate equation of the second degree:

$$G(r,t)=\left\{1-\left[1-\frac{1}{G_s(r)}\right]\exp\left[-\frac{1}{\Phi_s}\int_0^t I_{in}(r,t')dt\right]\right\}^{-1}$$

In disk amplifiers, I_{in} is multiplied by 1/n. $G_S(r)$ is r-dependent small signal gain, and Φ_S is the saturation parameter; when $\Phi_S = \gamma(h\nu/\sigma)$, γ is a variable parameter. This is because a single value cannot be set for Φ_S, since Nd ions have a number of different energy levels, and because saturation time at lower levels is proportional to pulse width and cannot be ignored.

2) Spatial Filters

When M is the magnification of a spatial filter, laser beam intensity after passing through the filter is $I(r,t) = T(B_S)\cdot I_{in}(r,t)/M^2$. Here the transmittance curve $T(B_S)$ is a function of the small-scale B integral B_S; Figure 1 is based on analysis of testing of spatial filter transmittance.[8] Nonlinear wave-front aberration immediately prior to input into the spatial filter depends on B_S and initial ($B_S = 0$) noise power fraction ε; there is high transmittance vis-a-vis B_S, which increases as ε decreases. Thus ε is thought to be a variable parameter which depends on the cleanness of the laser device. B_S is a function of instantaneous values (r,t), and so transmittance $T(B_S)$ also depends on (r,t), and transmittance is least when laser beam intensity is at its peak.

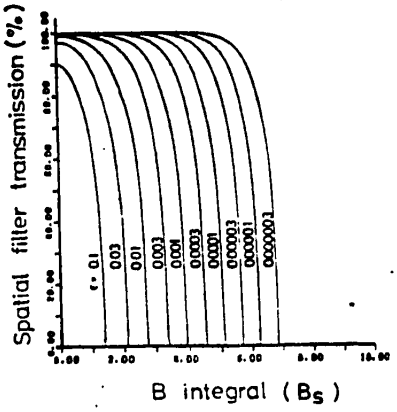

Figure 1. Transmission Function $T(B_S)$ of a Spatial Filter as a Function of Small Scale B-integral (B_S). ε is the initial fraction of noise power.

3) Other Optical Elements

Mirrors, Faraday rotators and shutters are all linear elements, and their characteristics, including polarization characteristics, can be expressed using a Muller matrix. They can be dealt with in the same way as multiple refractivity in rod amplifiers. We will omit the specific form of the matrix.

2.2 Limits of Application of the Code

This code will provide the laser beam's spatial intensity distribution as long as diffraction is not involved. It is possible to keep the diffraction effect to a minimum when the image transmission method is used, in which case the code is useful. But the diffraction effect when spatial filters isolate the high space-frequency component or the Fresnel diffraction resulting from long-range free propagation of the laser beam from the amplifier chain will require a separate integral. In a "dirty" laser system with many sources of optical noise, diffraction almost entirely dominates the laser beam intensity distribution, so more precise analysis becomes necessary. When there is little diffraction or optical noise, wholebeam self-focusing can be predicted by means of the code's B_T. There is not adequate test data on saturation characteristics of amplification in glass lasers, to include saturation time at lower levels, so it will be necessary to give more detailed experimental consideration to the appropriateness of the second degree equation used here.

3. Analysis of Results of Measurement of GEKKO XII Module Amplification Properties

We used the simulation code explained in paragraph 2 to analyze the results of measurement of GM-II amplification properties as described in I. Please refer to Figure 1 of I for the arrangement of GM-II. All the input parameters, including spatial distribution of amplifier gain dependence on pumping energy, were measured individually in advance. The initial values of the laser beam are taken as it emerges from the pulse generator, and spatial distribution and temporal wave form are Gaussian. The preamplifier chain (X-chain) aperture (AA) is super-Gaussian. The fill factor of the laser beam which has passed through the X-chain, including intensity distribution before entering AA, is about 0.6.

3.1 Amplification Properties With Pulse Width of 100 ps

Figure 2 plots output energy against input energy in the Y-chain with a pulse width of 100 ps. The open circles are measured points, and the solid curves are calculation results; they agree closely, including the absolute energy values. In this calculation, the variable parameter of Φ_s is set at $\gamma = 0.7$. Calculations are made with initial noise fractions of $\varepsilon = 0.0001$, 0.0003 and 0.001. The short vertical mark on each curve is the point at which the time-integrated transmittance of the spatial filter (SF-E in GM-II) of the amplifier chain falls below 96 percent. That is, as the input energy increases, output energy changes as shown in Figure 3; when the input energy is too great, the waveform is deformed without further increase in the output energy. The 96 percent transmittance mentioned above is represented by the third curve from the left of Figure 3. Thus, the region to the right of the short vertical marks,

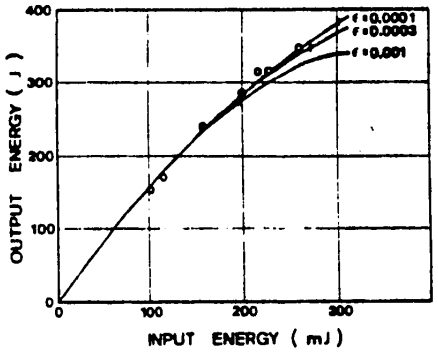

Figure 2. Output Energy of the Y-Chain vs the Input Energy at a Pulse Width of 100 ps. Open circles are experimental points and solid curves are calculation results for different amounts of initial noise fraction ε.

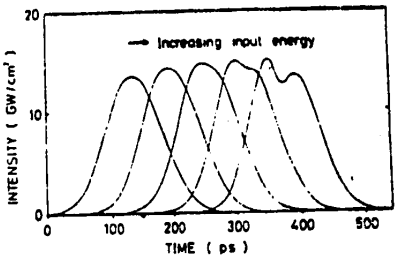

Figure 3. Temporal Output Pulse Shapes With Increasing Input Energies at a Pulse Width of 100 ps. Time origin has been shifted by 50 ps for each curve for clarification.

temporal and spatial waveform distortion increases with the input energy, so this point is considered as the maximum energy. When these results of calculation and of measurement are compared, we see that the $\varepsilon = 0.0001$ curve matches the measured values closely. Analysis and planning at Livermore Laboratory takes $\varepsilon = 0.001$ as the standard value; the difference may be that optical parts in GM-II were carefully controlled and optical noise was kept at a very low level. In the near field patterns of output laser beams shown in Figure 4 of I, unevenness of intensity distribution from optical noise is 20 percent at the most. But according to separate calculations of Fresnel diffraction, optical noise which produces that degree of unevenness is 0.1 or below in terms of phase (from a thickness of 1000 A or less with a refraction rate of 1.5) or 60 percent or more in terms of energy transmittance.[9] It is thus supposed that at least that degree of cleanness has been maintained in GM-II.

As a result of calculation of $\varepsilon = 0.0001$, it was concluded that when output is 346 J, $B_S = 2.2$ and the energy is sufficiently focusable. The ratio between peak and average values of the intensity distribution (the reciprocal of f) was 1.60, which is somewhat smaller than the measured value of 1.80. Thus it may be possible to obtain an output of nearly 4 TW if the spatial intensity distribution is improved. Under the above conditions B_T was 8.0, which corresponds to a wave-front aberration of about 1.3λ ($\lambda = 1.053$ μm); this gives rise to a shift in the focal point in the case of secondary spherical aberration, and to distortion of the intensity distribution of the focal point (this is dependent on time) in the case of nonspherical aberration.[5]

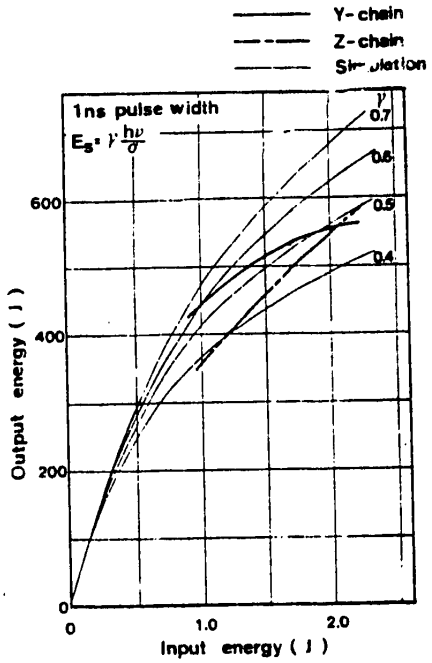

Figure 4. Comparison of Experimental Data and Simulation Calculation on Amplification Property of Y-Chain and Z-Chain at 1 ns. The parameter γ is a variable for different amount of saturation fluence.

3.2 Amplification Properties With Pulse Width of 1 ns

Variation of output energy is plotted against Y-chain and Z-chain input energy in Figure 4. Gain in the disk amplifiers is 5.5-fold for DA, 2.55-fold for DB and 2.25-fold for DC. The heavy line in Figure 4 indicates measured results for the Y-chain, and the broken line shows those for the Z-chain; the fine solid line is calculated with γ as the variable parameter. Neither of the measured values match the calculated values. The Y-chain, which uses LHG-7, is close to the $\gamma = 0.7$ curve with low input energy, but it shows great saturation as the input energy increases. But the Z-chain, which uses LHG-8, has a small signal amplification rate which does not agree with the calculations; it is thought that this is because there are portions which differ from properties of individual elements which were measured in advance and from the properties at the time of the system test. But aside from this point, the Z-chain measured results in Figure 4, and in Figure 6 of I, are close to the simulated curve for $\gamma = 0.7$ with high input energy. To summarize the above, LHG-8 fits the saturation parameter $E_S = 0.7\ h_\nu/\sigma$ relatively well, and LHG-7 has a small-signal saturation parameter of $E_S = 0.7\ h_\nu/\sigma$ and a large-signal saturation parameter of $E_S \sim 0.4\ h_\nu/\sigma$. The reasons for this are not known at present: it will be necessary to consider uneven spreading and transition time to the lower energy level of the laser, and to make further measurements of saturation characteristics, including the effect of variation of pulse widths.

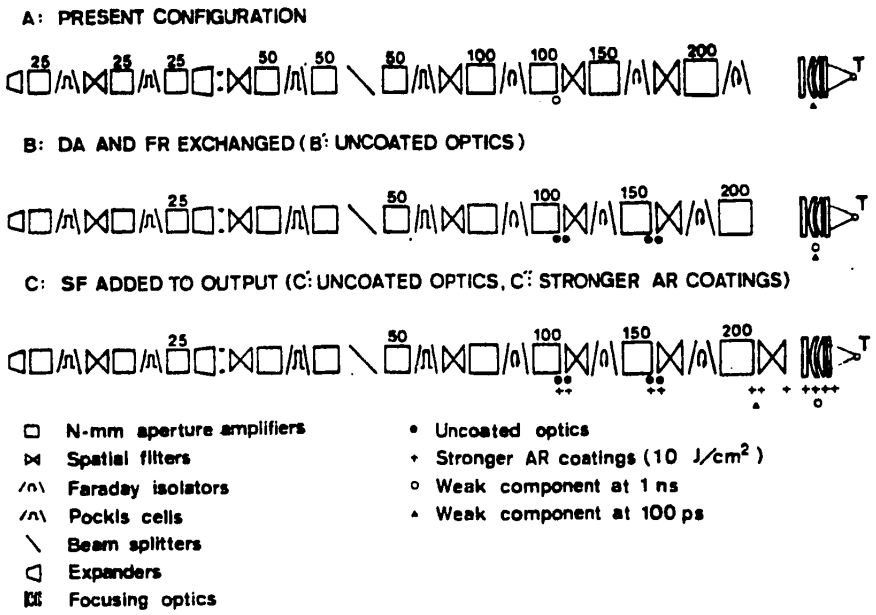

Figure 5. Comparison of Different Configurations for GEKKO XII Module. See the text for detailed explanation.

4. Configuration of GEKKO XII Module System

The above deals with properties of the laser section with the final Faraday rotator not in place. It is necessary to evaluate the energy actually focusable on the target when the FRC and target illumination optics are included. Plan A of Figure 5 shows the present configuration of GM-II. The target illumination optics include two mirrors (omitted from Figure 5), the target chamber vacuum seal glass, focusing lenses (F/2.75 doublet) and blast seal glass. Evaluation of the operating characteristics of this arrangement at pulse widths of 100 ps and 1 ns were made using the simulation code described in paragraph 2. The initial noise fraction was taken to be $\varepsilon = 0.0001$ and the saturation parameter to be $E_S = 0.7\ h_\nu/\sigma$. With a pulse width of 100 ps, the B value of the final focusing optical element (marked with an open triangle) is the limiting factor, and the focusable energy on target is limited to 172 J. With a pulse width of 1 ns, the limiting factor is the output window glass of disk amplifier DA (100Φ) and the input lens of the spatial filter (marked with an open circle); the maximum focusable energy is 839 J when 5 J/cm^2 is the damage threshold of the antireflective coating. At neither pulse width is it possible to develop the full capacity of the laser device, because pumping power must be kept below the maximum.

Then, in plan B, we exchanged the disk amplifier and the Faraday rotator, As shown in Figure 5, the limiting factor at 100 ps was still the optical element in the focusing lens, but the focusable energy increased to 208 J (see Table 1).

Table 1. Maximum Focusable Energy on a Target for the Different Configurations A-C". Also shown are weak components that limit the maximum performance.

	Focusable Energy		Weak Component	
	100 ps	1 ns	100 ps	1 ns
A	172 J	839 J	Focusing optics (B-limited)	DA(100^{ϕ})-2 window (5 J/cm^2)
B	208 J	847 J	Focusing optics (B-limited)	Focusing optics (5 J/cm^2)
B'	210 J	913 J	" "	" "
C	349 J	830	SF(200/200) input lens	Focusing optics (5 J/cm^2)
C'	296 J	876 J	(B-limited)	" "
C"	359 J	1770 J	" "	No damage (Input energy limited)

There was almost no change in operating characteristics at 1 ns, so uncoated glass of laser energy density was substituted (marked by filled circle). With this arrangement the focusing lens (with antireflective coating because of great reflection loss) was the limiting factor and output increased to 913 J.

In plan C, an equal magnification spatial filter was added to the laser output and the B_S value was reduced. With this configuration the focusable energy at 100 ps jumped to 349 J. Using uncoated optics (marked by filled circle) in plan C' did not increase output power much. But using optics with a stronger antireflective coating which could withstand 10 J/cm^2 (marked with + sign) allowed focusable energy of 1770 J at 1 ns. With this configuration it is possible to operate the amplifier chain at 90 percent of maximum pumping energy, and to get an even higher output by increasing oscillator output or by increasing amplifier pumping energy.

It is necessary to consider, for the different configurations, the light (and polarized light) reflected from the target back to the amplifier chains or transmitted light from other beams (directly exchanged polarized light) on the amplifier chains. The effects of these are shown in Table 2. Configuration A is completely protected because of the FRC in the final stage. In C", which provides the greatest output, the FRC polarizer is damaged when there is 32 percent reflectivity, but it is thought there will be no problem in reality, since this reflectivity measures reflected light which comes back with just the same directivity as the input light, and directivity of light reflected from plasma is normally not that good. All configurations are completely protected against transmitted light.

Table 2. Maximum Allowed Percentage of Reflection and Transmission of the Target for Different Configurations A-C". Also shown are weak components that are susceptible to laser damage.

	Focusable Energy	Maximum Reflectivity	Maximum Transmittance	Weak Component
A	839 J	100 percent	100 percent	No damage
B	847 J	61 percent	100 percent	DC (200^{ϕ})
B'	913 J	59 percent	100 percent	Input window
C	830 J	65 percent	100 percent	DC (200^{ϕ})
C'	876 J	64 percent	100 percent	Input window
C"	1770 J	32 percent	100 percent	FRC(200^{ϕ}) polarizer ($5\ J/cm^2$)

The above shows that to increase the focusable energy of GM-II it would be appropriate to add a spatial filter to the output and use stronger antireflective coatings. It was recently reported that separated glass surfaces have reflectivity below 0.2 percent and an extremely high damage threshold of about 12 J/cm^2 [10]; it is hoped that this can be put into practical application. In that event, high-reflection coatings (which now are stronger than antireflective coatings) will have to have the same degree of strength. Another approach is to increase the size of the output aperture of the output spatial filter, in which case focusing optics of present strength would do. The foundation of the above considerations is the damage threshold of the multilayered dielectric. During the testing a single sample was measured a number of times in different locations, and the minimum energy density causing damage was taken as the threshold value. But this damage threshold is a matter of resistance to a single shot; in actual use the laser beam will repeatedly strike the same location, so it may be necessary to operate at levels lower than shown in Table 1. To set numerical values for these levels, it will be necessary to measure film resistance to repeated laser illumination.

5. Conclusion

We have explained a simulation code for analysis and planning of a glass laser device and have used that code to analyze the measurements of GM-II amplification properties. If a low level of optical noise is hypothesized for short pulse (100 ps) operation of GM-II, measured values and calculated values match quite closely. This suggests that the low level of optical noise is a major factor in the high output energy developed in short pulse operation of GM-II. Measurements of long pulse (1 ns) operation do not really match simulation results. The saturation properties of LHG-7 differ greatly from measured values for LHG-8 and results of calculations using a simple model.

We also gave consideration to the configuration of GM-II, and learned that energy of 359 J at a pulse width of 100 ps and of 1770 J at 1 ns (single beams in each case) could be focused on the target by using antireflective coatings with a damage threshold above 10 J/cm^2.

The results of these studies were used as basic reference materials in the design of the GEKKO XII glass laser with output energy of 20 kJ.

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